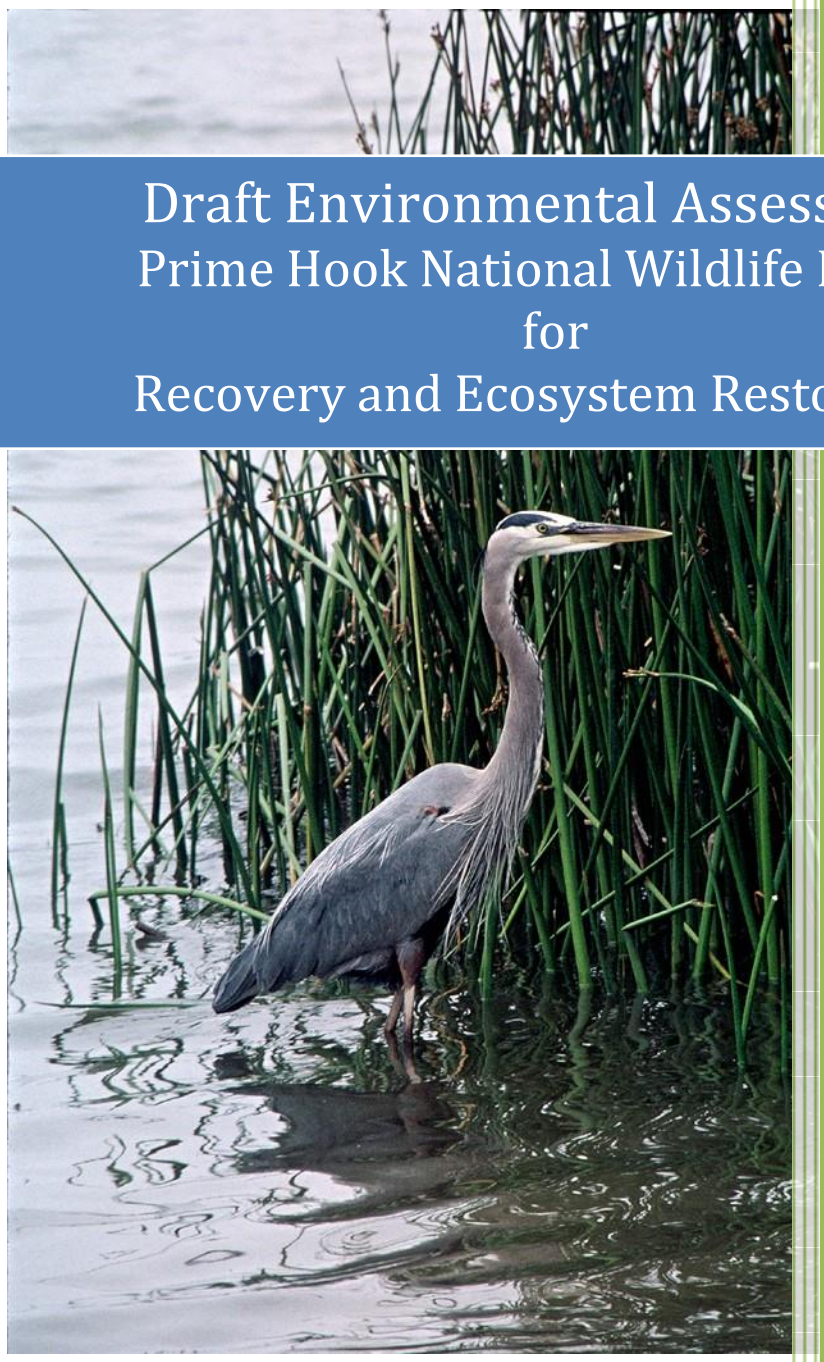
Draft Environmental Assessment
Prime Hook National Wildlife Refuge
for
Recovery and Ecosystem Restoration



U.S. Fish and Wildlife Service

February 2015

Draft Environmental Assessment
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Table of Contents **Page**

1.0 Summary 1
1.1 Purpose 1
1.2 Changes to the Project and Affected Environment (since the 2012 EIS) 1
1.3 Conclusion 1

2.0 Needs and Objectives of Action 2
2.1 Project Need and Purpose 2
2.2 The U.S. Fish and Wildlife Service, its Policies, and Legal Mandates, 4
2.2.1 Refuge Establishment, History, and Purpose 5
2.2.2 Previous National Environmental Policy Act Coordination 6
2.3 Existing Project Area 8
2.4 Alternatives Evaluation 17
2.5 Selected Plan 18
2.5.1 Beach Berm and Dune Restoration 23
2.5.2 Wetland Restoration 23
2.5.3 Borrow Area 24

3.0 Affected Environment 31
3.1 Geographic Setting 32
3.2 Geology and Hydrology 32
3.3 Surface Water Quality 34
3.4 Beach and Intertidal Habitat 37
3.5 Vegetation and Land Cover 38
3.6 Marine Resources 42
3.6.1 Placement Site and Borrow Area Sediments 42
3.6.2 Planktonic and Benthic Organisms 49
3.6.3 Fish 50
3.6.4 Essential Fish Habitat Assessment 52
3.7 Wildlife 55
3.8 Threatened and Endangered Species 57
3.9 Climate and the Influence of Sea Level Rise on the Physical Environment 59
3.10 Cultural Resources 60
3.10.1 Marine Existing Conditions 60
3.10.2 Nearshore Sand Borrow Areas 62
3.10.3 Terrestrial Existing Conditions 62
3.10.4 Dune and Beach Berm Construction 63
3.10.5 Wetland Restoration 63
3.10.6 Access Points and Staging Areas 63
3.11 Socioeconomic Environment 64
3.11.1 Environmental Justice 65
3.12 Air Quality 65
3.13 Hazardous, Toxic, and Radiologic Wastes 65
3.14 Noise 66

Draft Environmental Assessment
Prime Hook National Wildlife Refuge
For
Recovery and Ecosystem Restoration

Table of Contents (cont.) **Page**

4.0 Environmental Effects 67
4.1 Geographic Setting 67
4.2 Geology and Hydrology 68
4.3 Water Quality 69
4.4 Beach and Intertidal Habitat 70
4.5 Vegetation and Land Cover 71
4.6 Marine Resources 73
4.6.1 Borrow Area Sediments 73
4.6.2 Benthic Invertebrates 76
4.6.3 Fish 79
4.6.4 Essential Fish Habitat Assessment 80
4.7 Wildlife 84
4.8 Threatened and Endangered Species 85
4.9 Climate and the Influence of Sea Level Rise on the Physical Environment 90
4.10 Cultural Resources 91
4.10.1 Nearshore Sand Borrow Areas 91
4.10.2 Dune and Beach Berm Construction 92
4.10.3 Wetland Restoration 92
4.10.4 Access Points and Staging Areas 92
4.11 Socioeconomic Environment 92
4.11.1 Environmental Justice 93
4.12 Air Quality 93
4.12.1 General Conformity Review and Emissions Inventory 94
4.13 Hazardous, Toxic, and Radiologic Waste 94
4.14 Noise 95
4.15 Cumulative Impacts 96
4.16 Relationship Between Short-term Uses of the Environment and the Enhancement of Long-term Productivity 98
4.17 Unavoidable Adverse Effects 99
4.18 Potential Irreversible and Irretrievable Commitments of Resources 99

5.0 Environmental Regulations and Coordination 101

6.0 Literature Cited 103

7.0 List of Preparers 115

8.0 Evaluation of Section 404(b)(1) Guidelines 117

Appendix A: Atkins Water Levels Memorandum
Appendix B: Public Involvement and Agency Coordination
Appendix C: Air Quality Emissions Tables
Appendix D: Cultural Resources
Appendix E: Benthic Organisms Assessment

Draft Environmental Assessment
Prime Hook National Wildlife Refuge
For
Recovery and Ecosystem Restoration

Table of Contents (cont.) **Page**

Appendix F: Draft EA Comments and Responses
Appendix G: Draft Finding of No New Significant Impact (FONNSI)

Draft Environmental Assessment
Prime Hook National Wildlife Refuge
For
Recovery and Ecosystem Restoration

List of Figures **Page**

Figure 2-1: Prime Hook National Wildlife Refuge Overview and Vicinity Map 10

Figure 2-2: Historical aerial view of breach area in 2002 12

Figure 2-3: Historical aerial view of breach area in 2007 13

Figure 2-4: Historical aerial view of breach area in summer 2009 14

Figure 2-5: Historical aerial view of breach area in summer 2011 15

Figure 2-6: Historical aerial view of breach area in early 2013, following Hurricane Sandy 16

Figure 2-7: Water levels for seven initial restoration scenarios which combined various alterations to breaches, Fowlers Beach Road, and water control structures 20

Figure 2-8: Salinity over 6 months of model runs for a restoration scenario with all breaches closed, Fowler Beach Road intact, water control structures removed, and an initial salinity of 0 ppt 21

Figure 2-9: Salinity levels throughout the Refuge wetlands under the Selected Plan, with all breaches closed and the addition of both a main conveyance channel and secondary finger channels 22

Figure 2-10: Plan view of beach berm/dune and back barrier marsh platform (60% design) 25

Figure 2-11: Cross-section of beach berm/dune and back barrier marsh platform 26

Figure 2-12: Plan view of interior marsh excavated channels 27

Figure 2-13: Close-up plan view of the interior marsh excavated channels sidecasting areas 28

Figure 2-14: Cross section view of interior wetland excavated channels 29

Figure 2-15: Borrow Areas PHB-B, PHB-A, and PHB-C 30

Figure 3-1: Shoreline movement between 1937 and 2012 at Fowler Beach Road 33

Figure 3-2: Salinity transect measurements taken April 6, 2011 34

Figure 3-3: Salinity transect measurements taken December 1, 2011 35

Figure 3-4: Chlorophyll-a concentrations at seven sampling locations within Prime Hook National Wildlife Refuge during 2011 36

Figure 3-5: Eroded wetlands at Prime Hook National Wildlife Refuge, March 2014 38

Figure 3-6: National Vegetation Classification System Map of Prime Hook National Wildlife Refuge (2012) 40

Figure 3-7: Location of five beach sediment survey sample lines PHGS-1-PHGS-5 43

Draft Environmental Assessment
Prime Hook National Wildlife Refuge
For
Recovery and Ecosystem Restoration

List of Figures **Page**

Figure 3-8: Vibracore locations and sand depth for PHB-B, PHB-A, and PHB-C 47

Figure 3-9: Bottom surface sediment distribution for the Fowler Beach, Prime Hook Beach, and Borrow Area PHB-B regions 50

Figure 4-1: Vibracore locations and sand depth for Borrow Area PHB-B 75

Figure 4-2: Area PHB-B-major taxonomic contribution to benthic community composition 79

Draft Environmental Assessment
Prime Hook National Wildlife Refuge
For
Recovery and Ecosystem Restoration

List of Tables **Page**

Table 3-1: Status of Affected Resources 31

Table 3-2: ACES Placement Site and Borrow Area Characterization 44

Table 3-3: Summary of fish species captured in 2014 during summer and fall surveys throughout the project area 52

Table 3-4: Summary of Essential Fish Habitat designated species and their life stages within the Delaware Estuary Mixing Zone (Square 9307510) 53

Table 3-5: Faunal species that may be found at the Prime Hook National Wildlife Refuge project site 56

Table 3-6: Local economic effects associated with 2004 recreational visits 64

Table 3-7: Recreational expenditures and economic effects for the Prime Hook National Wildlife Refuge 65

Table 4-1: Results of epi-benthic tows at 5 stations sampled in Areas PHB-A, PHB-B, and PHB-C 78

1.0 Summary

1.1 Purpose

Prime Hook National Wildlife Refuge (NWR, refuge) is a 10,144-acre refuge established in 1963 under the authority of the Migratory Bird Conservation Act. Located on the west shore of the Delaware Bay, it provides an important stopover site for migratory birds that travel up and down the Atlantic Flyway, provides breeding habitat for federally and State-listed threatened and endangered species, as well as many neo-tropical migrating bird species. Hundreds of native plant and animal species thrive in its mosaic of diverse habitats. The refuge shoreline has incurred significant erosion and tidal flooding in recent years. The purpose of this Environmental Assessment (EA) is to present and evaluate the impacts of a site-specific proposed action for tidal marsh restoration, which was first included in the habitat management program analyzed in the Prime Hook NWR Comprehensive Conservation Plan/Environmental Impact Statement (CCP/EIS, 2012). This EA was prepared for the plan of breach repair and marsh restoration that was initiated in, and then further designed and modeled subsequent to the release of the CCP/EIS (2012).

1.2 Changes to the Project and the Affected Environment (since the 2012 EIS)

Superstorm Sandy exacerbated the rapid inundation of saltwater that has killed freshwater vegetation and enhanced elevation subsidence, biochemical changes, and further habitat loss. Due to its strategic location on the lower Delaware Bay, the importance of taking action to preserve and protect refuge lands has become all the more critical. Prime Hook NWR has national conservation significance as a designated RAMSAR Wetland of International Significance Site (1999), American Bird Conservancy-Important Bird Area (2000), and a Western Hemisphere Shorebird Reserve Network Site (1986). The refuge has lost, and continues to lose, acreage due in large part to its frontal dunes having been breached by storms. Building upon the 2012 EIS, alternative plans to address habitat losses and their impacts on the environment were modeled and developed and presented in this document. Evaluations of impacts on resources addressed previously in the CCP/EIS (2012) are not discussed in this EA and are incorporated by reference. Where appropriate, potential areas of concern have been re-evaluated and updated.

1.3 Conclusion

Based on the information presented in this EA and on evaluation and consideration of comments received on the CCP/EIS (2012) and an EA for Dune Work (EA, 2010), it is concluded that any changes to the project or changes to the physical conditions where the project will be constructed would have no new significant adverse effects on the human environment, over and above the potential environmental effects already addressed in the earlier EIS and EA. No significant adverse or new environmental effects are expected to occur as a result of the issues addressed in this EA.

The U.S. Fish and Wildlife Service (Service) is committed to working closely with Federal and State resource agencies, prior to and during project construction to continue monitoring and collection of additional environmental data, provide relevant supplemental information as needed, and to apply adaptive management and best management practices as appropriate. The U.S. Army Corps of Engineers (USACE) and the National Marine Fisheries Service (NMFS) are serving as cooperating agencies in the preparation of the NEPA documentation for this project.

2.0 Needs and Objectives of Action

2.1 Project Need and Purpose

This EA evaluates the impacts of changes to the physical environment and changes to the proposed project since completion of the previous EIS for the restoration plan of Prime Hook NWR. The Service had previously prepared an EA in 2010 to evaluate short-term, interim measures to restore protective sand dunes fronting the refuge wetlands. In 2012, the Service also prepared a combined CCP and EIS. The CCP was required by the National Wildlife Refuge System Administration Act of 1996, as amended by the National Wildlife Refuge System Improvement Act of 1997 (16 U.S.C. 668dd, *et seq*.; Refuge Improvement Act). The CCP addresses the management of natural resources at the refuge into the future. Under the National Environmental Protection Act of 1969 (NEPA), the 2012 EIS evaluates alternative measures to achieve the desired future condition of ecosystem protection and restoration. The EA (2010), EIS (2012), and current EA are required by NEPA as full disclosure documents of environmental effects of proposed federal agency actions.

The refuge provides critical resting, spawning, nesting, and feeding habitat for horseshoe crabs, migratory shorebirds, waterbirds, fish, reptiles, and mammals. Portions of the refuge consist of salt and brackish marsh habitat, impounded areas to provide freshwater wetlands, and other portions consist of upland early successional fields and forest habitats. As a consequence of severe storms, most recently in 2009, 2011, and 2012, several new sand breaches have opened along the bay front, causing erosion and flooding, while previous breaches have expanded and deepened. Over the past several years, portions of the impounded areas have reverted to saline conditions, largely due to these washover events and breaches during severe storms. Saltwater intrusion has had a dramatic impact on the former freshwater marshes, particularly in the middle area of the refuge (Management Units II and III). These areas now are comprised mostly of open water and areas of invasive common reed (*Phragmites australis*). Freshwater plants, intolerant of salt water, perished, resulting in the loss of vegetation and the rootmat that serves to stabilize sediments. Left unchecked, the transformation of marsh habitat to open water is expected to exacerbate shoreline erosion and flooding both within the refuge as well as in surrounding areas.

Back-barrier saltmarshes provide a platform on which beaches and dunes inevitably move naturally, and the geomorphological mechanism is well understood. These interactions between the sand barrier and back-barrier (saltmarsh) have been referred to as the "co-evolution" of barrier systems (Godfrey, 1976). The sand barrier system forms over time as a result of successive overwashes, whereby sediment inputs from the bay create overwash fans over older deposits and the barrier migrates (Rosati *et al*., 2006). The platform becomes vegetated and wetlands form, which traps sediments and creates peat over time, and stabilizes the platform further as wind-driven transport forms dunes over new deposits. Dunes reduce the erosion impact of wind, buffer the effects of floodwaters, and provide a sediment source to saltmarshes (Knutson, 1988; Odeum *et al*., 1984; Rosen, 1980). Back-barrier marshes are believed to slow the migration of barrier dunes as well, thereby creating a natural sustainable feedback system.

Estuaries trap sediment, most of which originates from erosion of land in the upper reaches of the watershed. However, the shoreline of the Delaware Bay is considered a sediment-starved beach system due to a variety of historical influences. The estuarine sediment system has been altered extensively in the last century. Extensive portions of once natural upper estuarine and river shoreline have been modified by construction of tributary mill dams, bulkheads, seawalls, piers, and wharves to serve the needs of urban and industrial development. Since about 1890, waterborne commerce has necessitated dredging and maintaining deepened channels, and most of the sediment dredged from the estuarine system has been placed in upland dredged material disposal sites (*i.e.* removed from the sediment

system). Over the past 50 years, there has been a progressive decline in the average annual volume of sediment removed from navigation channels by dredging with no reductions in maintained depths or any significant reduction in dredging projects requiring maintenance (pers. comm. J. Gebert, USACE, Philadelphia District). Fringing marshes along both the New Jersey and Delaware shorelines have experienced significant lateral retreat. Inadequate importation of suspended sediment, sea level rise (SLR), and to some extent, land subsidence, are believed to be the main causal factors (Kearnery *et al*., 2002; Stedman and Dahl, 2008; Cahoon *et al*., 2010).

Tidal wetlands provide some of the most productive natural ecosystems in the world, and are widely recognized for their important ecological functions. The services they provide include flood protection for coastal communities, maintenance of water quality, habitat for hundreds of species of fish and wildlife, and carbon sequestration. The historic activities that have had major effects on the exchange of water and waterborne sediment within marshes include dike construction to control tidal flows and create salt-hay farms, impoundments for waterfowl, and ditches for mosquito control. Normally, tidal wetlands can build vertically (accrete) in order to compensate for subsidence and/or SLR. This accretion occurs through the accumulation of organic matter (peat) from autochthonous below-ground root production as well as the importation and trapping of suspended sediments washing in with tidal or storm flows by saltmarsh vegetation. The importation and deposition of new sediments is essential to the long-term sustainability of coastal wetlands. The creation of freshwater impoundments in the coastal complex has exacerbated flooding and erosion problems in the refuge. Once inundated long-term vegetation dies off, leaving mudflats and open water areas that can no longer accrete sediments and keep pace with SLR.

Saltmarsh plants are perennials and develop thick root mats that trap sediments washed into the area, thereby enhancing land elevations to keep pace with rising sea levels. Freshwater marsh plants are annuals and although they produce larger quantities of organic matter, are vulnerable in coastal settings to storm events and die-offs due to saltwater intrusion.

The purpose of the proposed action is to promote recovery and ecosystem restoration of refuge wetlands to achieve three primary objectives:

> 1) restore the refuge's former impoundments to natural pre-impoundment conditions, enabling natural soil conditions to develop that are necessary for the intended saline natural plant communities that establish in coastal environments;
>
> 2) create or enhance saltmarsh habitats that will provide naturally for greater resilience to future storm damage and SLR; and
>
> 3) re-establish natural tidal flow and robust saltmarsh vegetation to the internal eastern portion of the refuge while maintaining freshwater input into more western portions of the refuge, primarily from Prime Hook Creek.

The combination CCP/EIS (2012) evaluated the socioeconomic, biological, physical, and cultural consequences of implementation of three alternative plans. A hydrodynamic numerical model was developed for the Service by Atkins to analyze restoration alternatives with respect to water levels, salinity patterns and circulation trends within the refuge. This modeling report (Atkins, 2014a) is available online at https://app.box.com/s/frclxl03g8a07diuxaq2 and summarized herein.

2.2 The U.S. Fish and Wildlife Service, its Policies, and Legal Mandates

The Service is an agency under the Department of the Interior (Department) and is the primary Federal agency responsible for conserving the nation's fish, wildlife, and their habitats through stewardship of lands. The Service administers the National Wildlife Refuge System (NWRS, Refuge System), encompassing more than 150 million acres of lands and waters in all 50 states and several island territories. The Refuge Improvement Act (RIA) was passed in 1997 and establishes a mission to determine compatible public use activities on the refuges, and the requirement to prepare a CCP for each refuge. As a result of international treaties for migratory bird conservation, such as the Migratory Bird Conservation Act, many refuges have also been established to protect migratory birds.

The following additional Service publications were evaluated in the development of the goals established for Prime Hook NWR in preparation of the CCP and proposed restoration plan:

The North American Waterfowl Management Plan (NAWMP, 1986) and updated in 1994, 1998, and 2004, to help protect continental habitat conditions that could sustain and improve waterfowl populations. The Plan calls for the protection of North America's remaining wetlands and restore waterfowl populations through habitat protection, restoration, and enhancement activities.

The Emergency Wetlands Resources Act (USFWS, 1986) was enacted to promote the conservation of wetlands nationwide and develop a priority conservation plan. In 1990, the Service's Northeast Region completed a concept plan that identified 850 wetland sites that warranted consideration for acquisition. Eight of the sites are located in Sussex County, while two of these are located immediately adjacent to the refuge.

Partners in Amphibian and Reptile Conservation (PARC, 2000) is a partnership of diverse public and private organizations with a comprehensive herpetofauna conservation effort, providing the best available science for the conservation of habitats and species.

*The Northern Atlantic Regional Shorebird Plan (*Clarke *et al.*, 2001) was produced at the regional level from the *U.S. Shorebird Conservation Plan*, developed with the purpose of creating conservation goals, identifying critical habitat, and promoting education and outreach programs to facilitate shorebird conservation. The Regional Plan identifies Prime Hook NWR as part of the Atlantic Flyway, which includes 12 states, and extremely important for transient shorebirds during their northbound and southbound migrations.

The North American Waterbird Conservation Plan (NAWCP) (USFWS, 2002) provides a continental framework for individual and institution partnerships to conserve and manage 210 species of waterbirds utilizing aquatic and wetland habitats.

A Process for Integrating Wildlife Population, Biodiversity, and Habitat Goals and Objectives of the NWR System: Coordinating with Partners at all Landscape Scales (USFWS, 2004) was completed to recognize conservation biology principles and how they would apply to each refuge to best contribute to maintaining biodiversity.

The Partners in Flight (PIF) North American Landbird Conservation Plan (Rich *et al.*, 2004) reviews the conservation status of 448 native landbird species to establish priority conservation concerns due to habitat declines. Of the 100 watch list species, at least 11 are present within the Prime Hook NWR.

The *A Blueprint for the Future of Migratory Birds: A Strategic Plan 2004-2014* (USFWS, 2004) was published as a 10-year national strategic migratory management plan to collaborate with partner to recommit to migratory bird conservation. The Strategic Habitat Conservation (SHC) approach formulates proposed refuge-specific habitat objectives, and provides an adaptive conservation management scheme with continued refinement to achieve desired outcomes and examination of consequences.

Atlantic Coast Joint Venture (USFWS, 2005): a step-down approach of the continental and regional goals of the 2004 NAWMP and present a current status assessment of waterfowl and their habitats within the joint venture, and update focus area data for each state to present habitat conservation goals.

Publication of the Birds of Conservation Concern (USFWS, 2008). The 1988 amendment to the Fish and Wildlife Conservation Act mandates that the Service identify species of migratory birds that, without additional conservation actions, would be likely to become candidates for listing under the Endangered Species Act (ESA) of 1973.

Fulfilling the Promise, The National Wildlife Refuge System: Visions for Wildlife, Habitat, People and Leadership (USFWS, 1999) offered recommendations such as forging new alliances through citizen and community partnerships and strengthening partnerships with the business community.

Conserving the Future: Wildlife Refuges and the Next Generation (USFWS, 2011) builds upon the framework established through coordination with the public to establish partnerships with respect to conservation in a world possessing a more diverse population, a challenged economy, a changing climate, and U.S. involvement in war.

The RIA identifies six wildlife-dependent public uses: hunting, fishing, wildlife observation and photography, environmental education and interpretation to receive priority consideration on refuges. The Refuge System Manual provides a central reference for current policies governing the operation and management of the Refuge System, including technical information on implementing refuge policies and guidelines. Much of the information discussed in this report has been evaluated and presented in the CCP/EIS (2012), and for the sake of brevity is incorporated by reference and will not be repeated in detail herein. New information is presented in detail in this report, and where appropriate, potential areas of concern have been re-evaluated and updated.

This project was previously vetted and approved for funding by the Department. The appropriation for this project is the Hurricane Sandy Disaster Relief Supplemental Appropriation Act of 2013, Public Law 113-2. Criteria for funding was based on the project's ability to yield the greatest return on investment by taking advantage of existing science and regional planning tools for resiliency and by working with states, cities, communities, and partners who contribute to the goals of restoring and rebuilding national wildlife refuges and other Federal public assets; and to increase resiliency and the capacity of coastal habitat and infrastructure and to withstand future storms and to minimize the damage incurred.

2.2.1 Refuge Establishment, History, and Purpose

Prime Hook NWR was established in 1963 under the authority of the Migratory Bird Conservation Act (16 U.S.C. 715-715r), as amended in southeastern Delaware. The refuge boundaries were later expanded through purchase of land through funding from the Land and Water Conservation Fund, under the authority of the Refuge Recreation Act (16 U.S.C. 460k-460k-4), as amended, and currently encompasses 10,144 acres. The refuge, situated on the western shore of the lower Delaware Bay, consisted historically of tidal saltmarshes and agricultural lands (*i.e.* corn and small grains farm fields and cattle grazing).

Surrounding areas were also dominated by small farms. Today, the refuge is bordered by residential development.

Eighty percent of the refuge is comprised of emergent wetlands and impounded freshwater areas of red maple, Atlantic white cedar, and seaside alder swamps. The remaining area consists of about 700 acres of upland mixed pine and hardwood forest, 600 acres of farmed fields, and 700 acres of early successional habitats. Over the years, the Service's management was designed to maintain freshwater habitats to maximize migratory waterfowl production and the impoundments were constructed in the 1980s. Game agencies use farming to attract waterfowl on wildlife management areas. The refuge initiated a cooperative farming program in the 1960s when the refuge was first established and by the 1970s, 1,070 acres were farmed until the program ended 2006.

The Service's primary purpose in managing the refuge is to conserve a diversity of fish, wildlife, and plants through the protection of the network of habitats necessary for these natural resources; and provide and enhance opportunities for participation in compatible wildlife-dependent recreation while fostering understanding and appreciation for the value of these ecosystems and their natural inhabitants to the human condition. Biological diversity within the refuge is dependent upon preservation, restoration and enhancement of its historical habitats. The vision statement below describes the Service's desired future character of the refuge and was developed through coordination and input from cooperative partners and the public:

Prime Hook NWR will comprise a variety of Delmarva coastal plain habitats, such as barrier island beach, freshwater wetlands, tidal salt marshes, grassland, shrubland, and forest. The refuge will manage, maintain, enhance, and, where appropriate, restore ecologically sustainable habitats for native plants and animals, with an emphasis on migratory birds and rare species. A balanced approach will be used to ensure all wildlife-dependent recreational users experience quality opportunities. The refuge will be a leader in conservation, research, and community partnerships, adapting to physical and natural changes as necessary to maintain the ecological integrity of the refuge and build a stewardship ethic for current and future generations.

2.2.2 Previous NEPA Coordination

Final Environmental Assessment for Dune Work (2010). The Service proposed, as a short-term interim measure, moving sand within washover areas within the refuge and from off-site sources to augment dunes along the bayfront in an effort to re-establish water management capability and provide added protection of the interior marshes vulnerable to frequent flooding.

The Comprehensive Conservation Plan and Environmental Impact Statement (2012). The Service's planning policy provides guidance, systematic direction, and minimum requirements for developing a CCP for the management of the refuge and to fulfill the Refuge System mission. The CCP uses sound science, as directed under the RIA, to define the refuge's fish, wildlife, and plant populations and habitats, as well as the refuge's distribution and migration patterns and objectives. Also incorporated into the CCP are the refuge's archaeological and cultural values; areas suitable for administrative or visitor facilities; and any significant problems that may adversely affect species and their habitats so as to identify actions necessary to mitigate such problems. The CCP will be reviewed and updated every 15 years, in accordance with the RIA and Service planning policy (602 FWS 1, 3, and 4). However, when significant new information becomes available or ecological conditions change, the plan can be reviewed sooner. All plan revisions require NEPA compliance. If minor plan revisions are required and they meet the criteria of a categorical exclusion, then an environmental action statement, in accordance with 550 FW

3.3C will only be required. But if the plan requires a major revision, then the CCP process starts anew at the preplanning step (602 FW 3.8B).

The Service's CCP policy establishes an eight-step planning process that facilitates compliance with NEPA and preparation of the EIS (refer to Chapter 2; page 4 of the CCP/EIS, 2012). Open houses and public information meetings were held throughout the area prior to and during the development of the CCP/EIS and provided participants the opportunity to learn about the refuge plan. The public information meetings provided a presentation of the refuge, a brief review of the Refuge System and the planning process, and a question and answer session. These public meetings also provided the refuge staff the opportunity to gather information and ideas from local residents, adjacent landowners, and various organizations and agencies. Visitor and community surveys were developed to enable written comments on topics of concern, such as wildlife habitats, exotic nuisance species, and public access. The draft CCP/EIS was presented in August 2012. All public meeting notes, comments, letters and emails were evaluated. Substantive comments and responses received are provided in Appendix L of the CCP/EIS, which was completed in December 2012. The Record of Decision (ROD) was signed 29 March 2013.

The NEPA of 1969, as amended (Pub. L. 91-190, 42 U.S.C. 4321 *et seq*.) is the basic national charter for protection of the environment and ensures that relevant information is available to the public before decisions are made and actions are taken. The NEPA process is implemented to identify and assess the reasonable alternatives to proposed actions that will avoid or minimize adverse effects of these actions upon the environment. The combination CCP/EIS (2012) presents a full disclosure analytical evaluation of environmental impacts of the proposed plan and is used by Federal officials in conjunction with other relevant material to plan actions and make decisions. After an evaluation of alternative plans, including the No Action Alternative, and alternatives considered but eliminated through detailed analyses, the Service identified a preferred plan in the CCP/EIS (2012).

This EA was developed to address new information and new circumstances to the environment and further details or changes to the proposed plan after the final EIS had been completed in order to make a determination as to whether these result in new significant environmental impacts that were not evaluated in the EIS. Where there is uncertainty of the significance of potential new impacts, appropriate environmental studies were conducted to assess the impacts of the changes, new information or new circumstances. This EA, in accordance with CEQ regulations, examines whether the new information indicates that there are "substantial changes in the proposed action that are relevant to environmental concerns" or "significant new circumstances or information relevant to environmental concerns and bearing on the proposed action or its impacts" that either were not fully discussed or did not exist at the time the EIS was prepared (40 CFR 1502.9).

Federal agencies are encouraged to tier their NEPA analysis to avoid repetition of issues and to focus on the issues for decision at each level of review. Tiering is appropriate when the sequence of statements or analyses is from a plan EIS to a site-specific analysis. The EA tiers to the 2012 EIS (and 2013 ROD) in accordance with 40 CFR 1508.28, and finds that the conditions and environmental effects described in the earlier NEPA documents are still valid or address any exceptions. "An environmental assessment may be prepared, and a finding of no significant impact reached, for a proposed action with significant effects, whether direct, indirect, or cumulative, if the environmental assessment is tiered to a broader environmental impact statement which fully analyzed those significant effects. Tiering to the programmatic or broader-scope environmental impact statement would allow the preparation of an environmental assessment and a finding of no significant impact for the individual proposed action, so long as any previously unanalyzed effects are not significant. A finding of no significant impact other than those already disclosed and analyzed in the environmental impact statement to which the

environmental assessment is tiered may also be called a 'finding of no new significant impact.'" (43 CFR 46.140). This cuts down on bulk without impeding agency and public review of the proposed action. Portions of the original EIS that are unchanged and are still valid will be briefly summarized and referenced, and therefore reflect an up-to-date consideration of the entire proposed action and its effects on the environment. The Final CCP/EIS can be accessed at http://www.fws.gov/refuge/Prime_Hook/what_we_do/finalccp.html.

NEPA mandates that the lead agency (the Service) supervise the preparation of the EA if more than one Federal agency is involved in the same action. Federal, state, or local agencies may act as joint or cooperative partner agencies to prepare the EA, typically determined by letter of memorandum. In April 2014, the Service requested the USACE, Philadelphia District Civil Works divisions to assist, in partnership, in the development of several key components of the proposed restoration project: agency coordination, document preparation, and the design, contracting, and construction of the foreshore and frontal dune complex and back barrier marsh platform. The Service also requested the USACE Regulatory Branch and the NMFS to participate as cooperating agencies in the preparation of this document. Both agreed to serve as cooperating agencies for the project (see Appendix).

2.3 Existing Project Area

Prime Hook NWR covers 10,144 acres, stretching along the southwestern coastline of Delaware Bay, just north of Cape Henlopen in Sussex County, Delaware (Figure 2-1). The refuge's eastern boundary runs next to three beachfront communities: Slaughter Beach, Prime Hook Beach, and Broadkill Beach, with some agricultural lands. Eighty percent of the refuge's vegetation cover types are characterized by tidal and freshwater creek drainages that discharge into the bay and associated coastal marshes. Wildlife habitat types, as delineated in the Delaware comprehensive wildlife management plan (DeWAP, 2006), include unvegetated sandy beach, dune grasslands, interdunal wetlands, *Spartina* high salt marshes, intertidal mudflats, *Spartina* low salt marsh, bishopweed mixed species, brackish marsh, freshwater impoundments, red maple/Atlantic white cedar/seaside alder swamps, mixed herb deep peat wetlands, forested wetlands, early successional uplands, and ancient sand ridge forests. These cover types provide habitat for over 300 species of birds, over 50 species of fish, 45 species of reptiles and amphibians, 37 species of mammals, and an array of insects and plants.

The refuge is divided into four Management Units that include open water areas, wetlands and associated uplands:

Unit I comprises the northern most end of the refuge and is delineated by Slaughter Beach Road as its northern boundary, overwashed barrier dunes, and some houses in the community of Slaughter Beach on the east, Fowler Beach Road on the south, and an upland fringe of scrub-shrub areas on the western boundary. There is currently no water level management capability in Unit I, which contains about 1,400 acres of salt marsh. Tidal saltwater is the primary source of water for the unit, which flows approximately 2 miles from the Delaware Bay through the Mispillion Inlet and into Cedar Creek, entering through Slaughter Canal.

Attenuated tidal flow provided by Slaughter Canal bisects Unit I and receives its afflux from the ditches and creeks within the salt marshes in Unit I. The Draper-Bennett Tax Ditch drains the southwestern portion of this unit, which ultimately feeds into the Slaughter Canal. Daily tidal action has a 4.4-foot range and salinities range from 5 to 25 parts per thousand (ppt) in the canal. During drought periods, the salinity can get as high as 30 ppt. Rainfall, new and full moon tides, and spring and neap tides maintain the salt marsh community within Unit I. Natural formations of inlets from overwash events along the bay

shoreline rejuvenate tidal marsh habitats in Unit I through maintenance of salinity levels and deposition of nutrients and sediments carried by tidal flow. Over the past 100 years, the dune line has been overwashed several times along this shoreline. Recently, a breach in the southern portion of Unit I has restored tidal flow into the unit east of the Slaughter Canal.

Unit II is just south of Unit I and has been managed as an impounded, nontidal freshwater system that is manipulated by water control structures. It is bounded on the north by Fowler Beach Road, barrier dunes, and the Prime Hook Beach community on the east, Prime Hook Road on the south, and an upland interface on the west. During storm tides this sand dune system has been breached several times and washouts have deposited sand and salt water into the Unit II impoundment. Freshwater input is from Slaughter Creek, which flows from the west. Delaware Bay's normal tidal ranges are from 3 to 3.5 feet (ft), except for storm surges and spring tides (± 6.5 ft).

Tidal flow enters Slaughter Canal from the Delaware Bay through Unit I salt marshes into the northern portion of Unit II and through the breach along the shoreline. Fresh water flow enters Unit II on the west from Slaughter Creek and from Unit III to the south.

Landowners had the marsh drained and dug Slaughter Canal in the early 1900s to improve drainage of their upland areas by channelizing water north to Cedar Creek. In 1906, the Slaughter Canal dredging reached into Unit II and ended at Oak Island. Portions of Unit II were also heavily grid-ditched during the 1930s for mosquito control. To maintain water on the marsh during the fall and winter for muskrat trapping and waterfowl hunting, private owners built water control structures at Fowler Beach Road, Oak Island, and near the bridge at Slaughter Creek to hold water.

Unit III is bounded by Prime Hook Road on the north, Route 16 (Broadkill Beach Road) on the south, upland edge on the western boundary, and the Prime Hook and Broadkill Beach developments immediately adjacent to the refuge's eastern boundary. Unit III consists of roughly 3,600 acres, which include impounded freshwater emergent marsh, red maple-seaside alder swamp, low-lying farmed areas, brush, barrier beach on the east, and 140 acres of flowage easement (tract numbers 84R, 99F and 99i) on the southeastern boundary of Unit III. This flowage easement drains directly into Prime Hook Creek and flows south to the water control structure of this watercourse. Twenty-five hundred acres of marsh were impounded in the 1980s to create the freshwater marsh it is today.

More than 100 years ago, Unit III was a tidal marsh system with several small creeks and abundant potholes where Prime Hook Creek and Deep Hole Creek drained directly into the Delaware Bay (1.5 miles north of current Prime Hook Creek water control structure) (USFWS, 1982). A major storm in 1911 plugged and sealed the Deep Hole Creek and Prime Hook Creek outlets to the Delaware Bay. The closing of these two outlets drastically changed the daily tidal influence and hydrology of Unit III. Prime Hook Creek now flows through the Petersfield Ditch to empty into the Broadkill River, which drains into the Delaware Bay about 2 miles south of the present-day refuge.

Figure 2-1: Prime Hook National Wildlife Refuge Overview and Vicinity Map.

Unit IV is surrounded by Route 16 on the north, the Broadkill Beach community on the east, the Broadkill River on the south and west, and the upland edge on the west. Prior to Service ownership, this marsh had been excessively drained by man-made ditches. When the refuge was established, about 1,000 acres of tidal salt marsh surrounded about 150 acres of farm fields. Before 1963, private owners maintained pumping stations for ponds in Units III and IV for cattle and to manage waterfowl and muskrats. The Broadkill River is tidal, with salinity ranges from 10 to 30 (ppt). The majority of the water for Unit IV is provided through the Broadkill River. Some tidal action and leakage of salt water into the Unit IV impoundment also occurs during peak tides from a ditch connected to the Broadkill Sound. Rainfall and runoff from Unit III are other sources that provide fresh water. However, normal runoff and tidal action are not sufficient to recharge the impoundment above its perimeter elevation.

Prime Hook NWR provides important natural features along the western Delaware Bay front and to the region as a whole. Located directly along the North American Atlantic Flyway, the area provides critical stopover sites for migratory birds and habitat for many species of fish and wildlife. Units II and III historically possessed salt and brackish marshes, but due to diking in the early 1980s to create freshwater impoundments, these units have succumbed the most to severe storm events causing flooding, erosion and subsidence from overwashes and breaches. The resulting effect in Units II and III has been a shift from freshwater marsh to open saltwater, for the most part, as the re-establishment of saltmarsh has been slow due to the altered conditions (*i.e*. loss of sediment, subsidence and oxidation and dispersal of organic soils). In 2006, a single overwash sand fan formed just north of Fowler Beach Road in Unit I. By fall 2009, this overwash had breached and two more overwash fans breached south of Fowler Beach Road in Unit II. By 2011, the original breach in Unit I had begun to fill in, but Hurricane Irene widened the two breaches south of Fowler Beach Road. By 2013, the original breach in Unit I had closed but two new breaches resulted from Hurricane Sandy, for a total of four breaches present currently in Unit II (Figures 2-2 through 2-6).

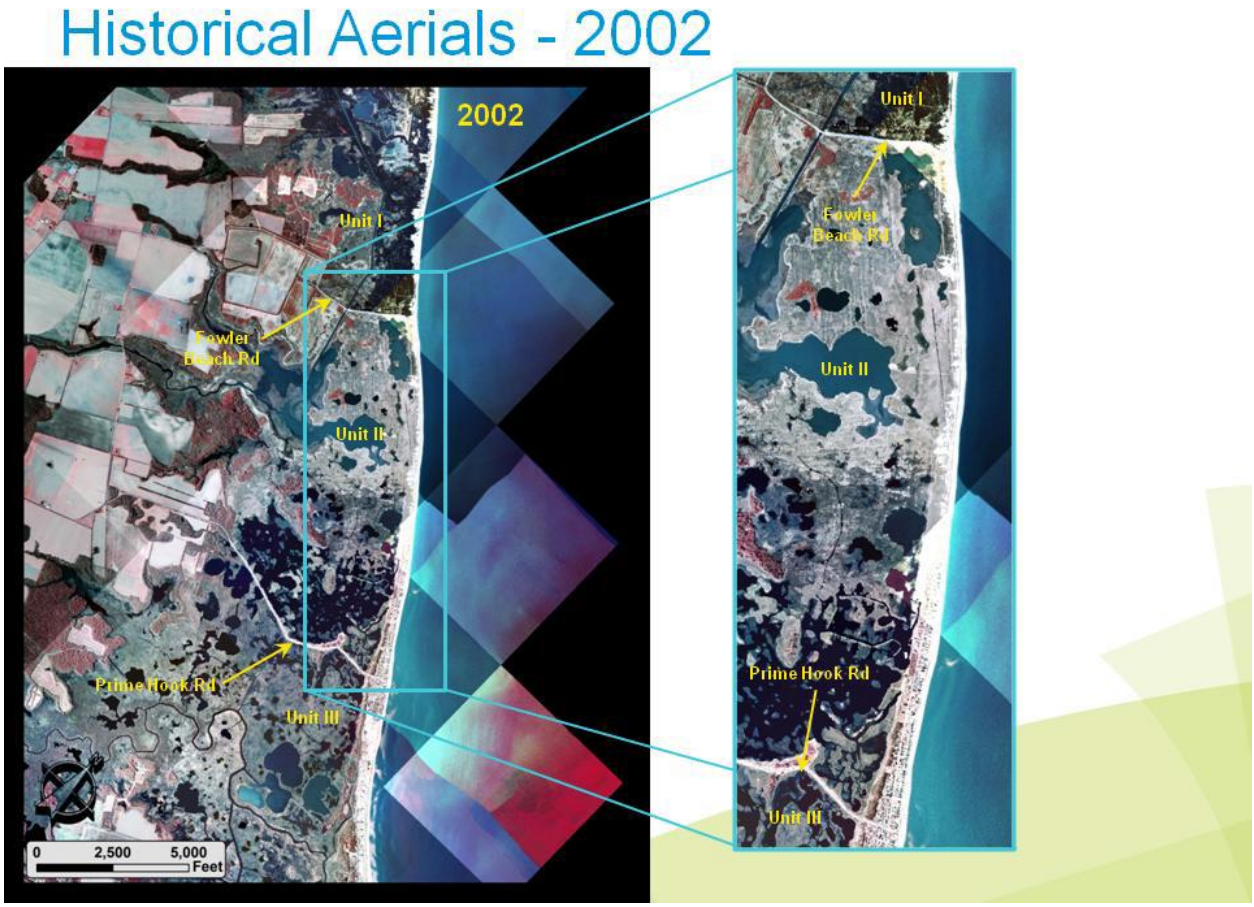


Figure 2-2: Historical aerial view of breach area in 2002 (Atkins, 2014a).

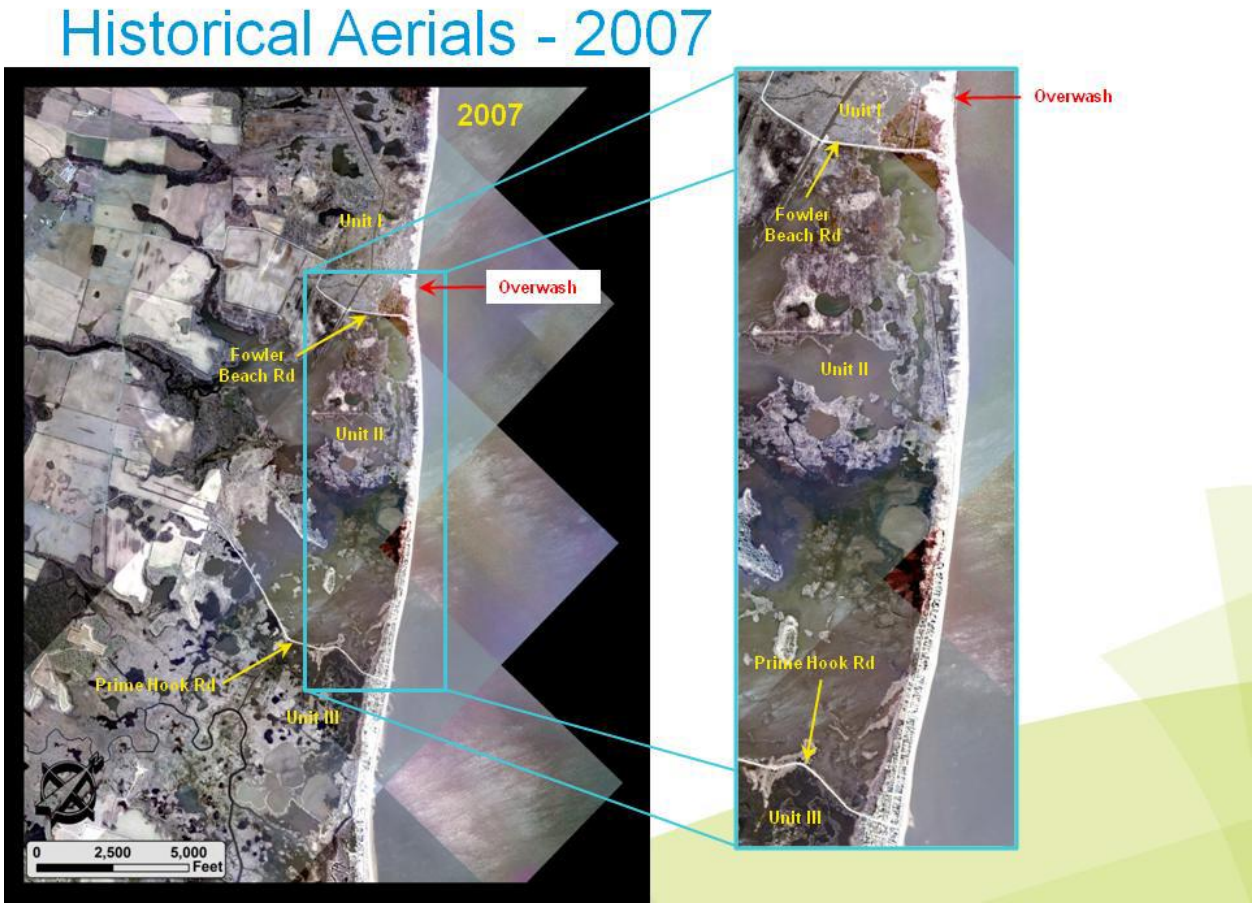


Figure 2-3: Historical aerial view of breach area in 2007 (Atkins, 2014a).

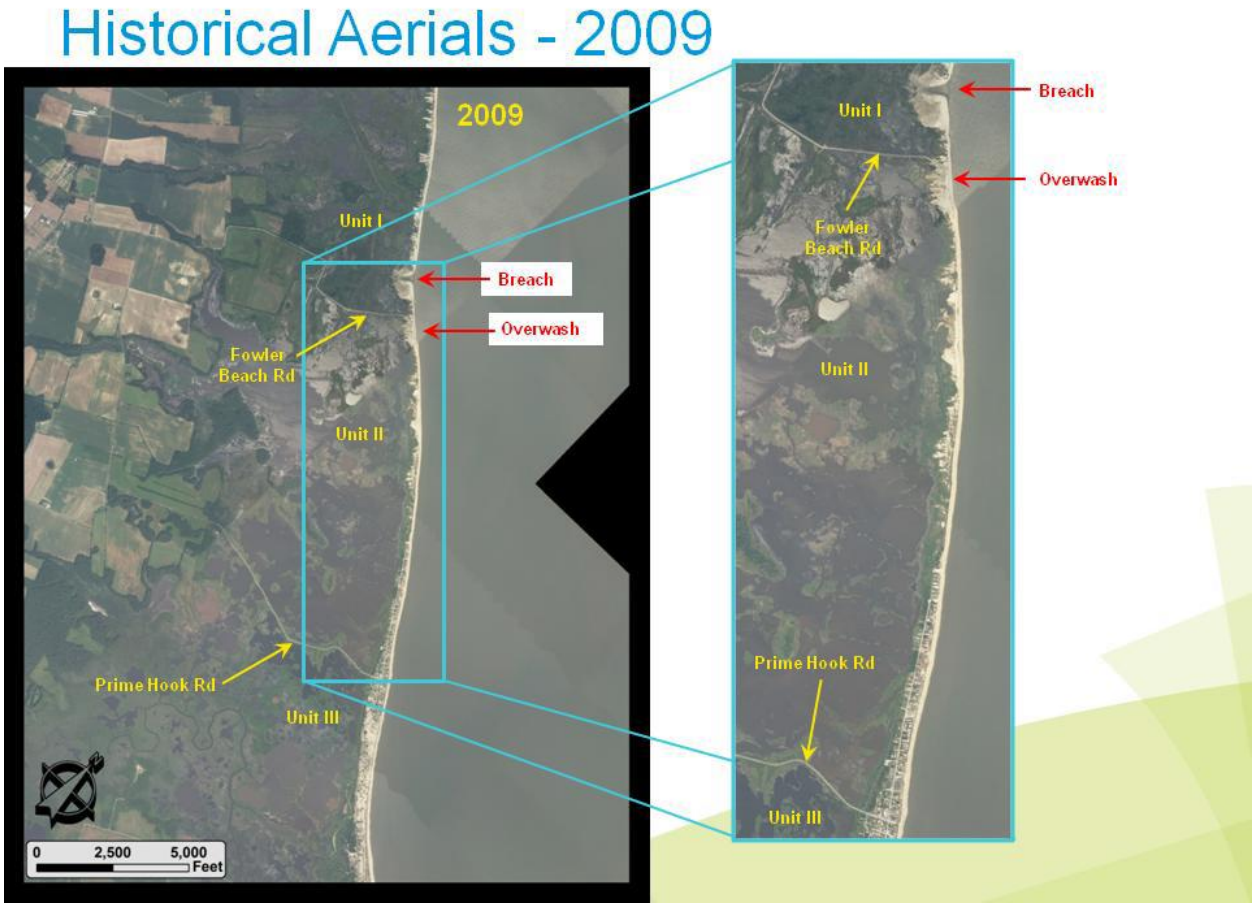


Figure 2-4: Historical aerial view of breach area in summer 2009 (Atkins, 2014a).

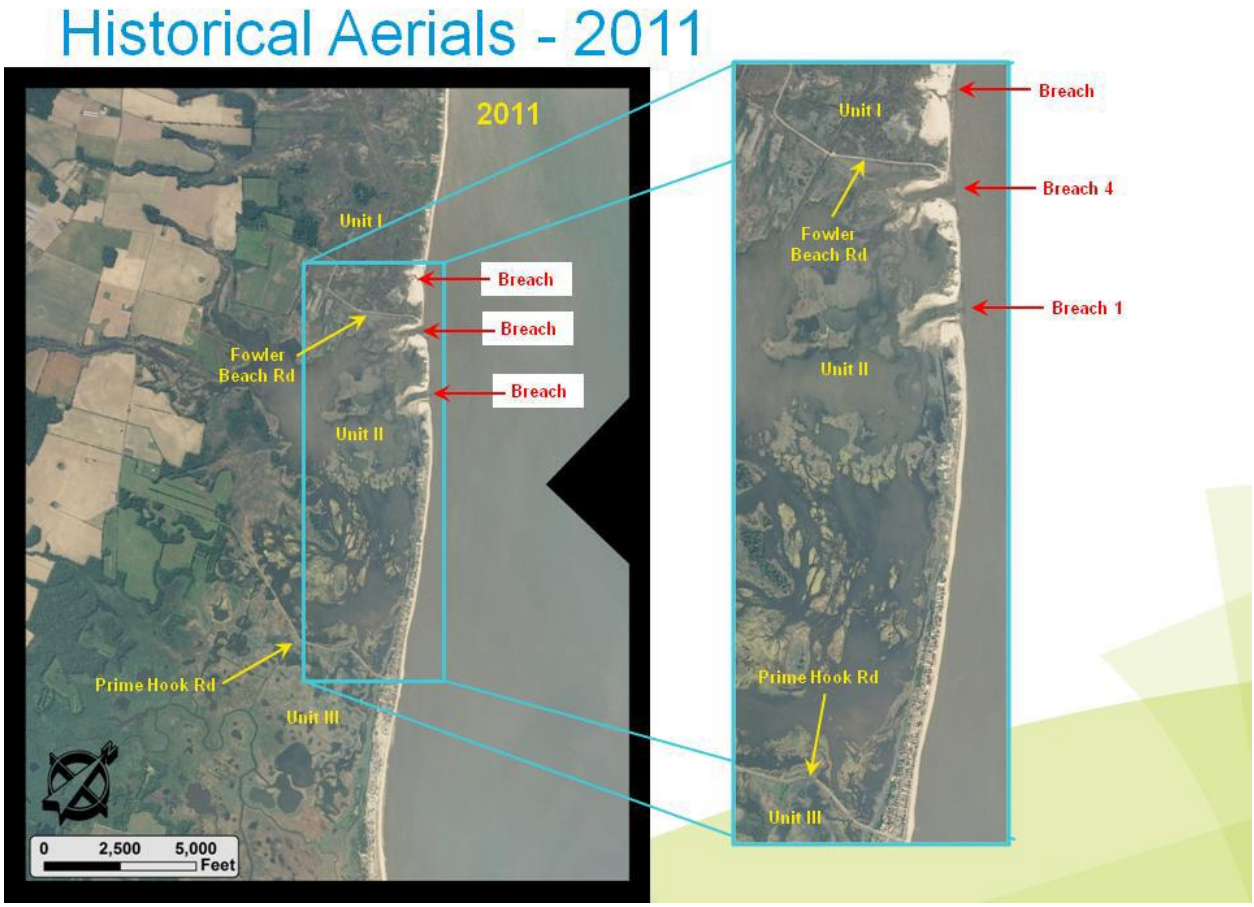


Figure 2-5: Historical aerial view of breach area in summer 2011 (Atkins, 2014a).

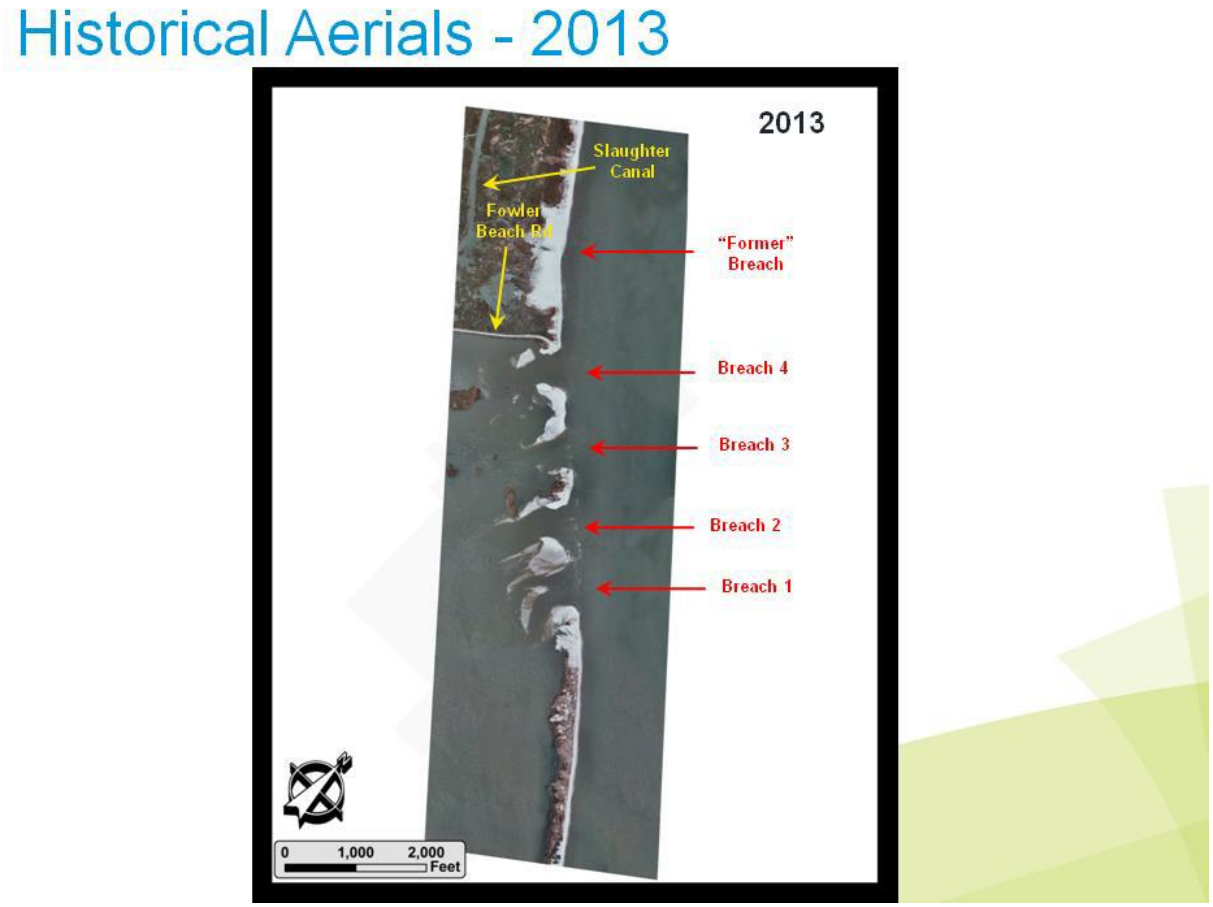


Figure 2-6: Historical aerial view of breach area in early 2013, following Hurricane Sandy (Atkins, 2014a).

A study produced for the Delaware Department of Natural Resources and Environmental Control (DNREC) by Atkins (2009) characterized the shoreline of Delaware Bay in the region of the refuge as "sediment-starved" with net transport from the north to the south. In recent years, the Delaware Coastal Program (DCP) has been collecting monitoring and research data at the refuge wetlands. Aerial imaging of the shoreline over the past 80+ years shows the rate of shoreline erosion has been increasing in recent decades. Radiometric isotope analysis of sediment cores throughout the refuge wetland complex reveals historic accretion rates in Unit II and Unit III that are the lowest in the State, and are approximately half of the current rate of sea level rise in the area, creating an accretion deficit over recent decades. The elevations in many areas of Units II and III are just at or below the optimal growth range for *Spartina alterniflora*, and the marsh surface is continually submerged under current conditions, which would make natural revegetation of most of the wetland complex unlikely without proactive marsh restoration. Higher elevations and higher historic accretion rates (*i.e.* keeping pace with or exceeding sea level rise) in Unit I may be a result of periodic breaching and nourishing of marshes from bay sediments.

2.4 Alternatives Evaluation

This section summarizes the procedures implemented in the development of the CCP/EIS (2012). All actions considered but eliminated from detailed analyses, such as hard armoring of the shoreline, land acquisition, and acquisition boundary expansion, are presented in chapter 4 of the CCP/EIS, 2012.

The three remaining alternatives evaluated in the CCP/EIS 2012 compare how each one addresses the significant issues, supports the Service's programs, and achieves refuge goals: Alternative A (the No Action Alternative/Current Management); Alternative B (Preferred Alternative: berm/dune/wetland restoration); and Alternative C (Historic Habitat Management). Detailed discussion of the Alternative strategies, objectives, and loss of refuge functions are evaluated in chapter 4 of the CCP/EIS and summarized below.

Alternative A: The No Action alternative proposed no change in the current management of the refuge; assumed few proactive efforts; and future habitats would continue to result from natural events and earlier human manipulations of the marshes. Alternative A would maintain the refuge's existing management activities and public use programs, and serves as the baseline for comparing and contrasting Alternatives B and C. Loss of refuge habitats by inundation would most likely continue to occur due to storm and tidal inundation under the No Action Alternative.

Alternative B: The Service-preferred alternative entails habitat restoration through both passive and active management approaches. Marsh restoration strategies proposed and evaluated included the restoration of marsh platform elevations and the creation of tidal channels to deliver tidal sea water to the marsh system in a manner conducive to the natural establishment of saltmarsh vegetation. These beach and marsh restoration options were further analyzed and refined subsequent to the CCP/EIS and are described in this report. Both the beach and marsh restoration elements in combination are deemed critical to greater resiliency to future storm damage and promote adaptation to SLR impacts. The cost/benefit analysis for this alternative is positive amortized over a 30-year project life period. For a complete evaluation of the economic benefits to the local and regional economy for the alternatives considered, refer to Appendix I of the CCP/EIS, 2012).

The goals of the preferred alternative are to preserve extant marshes, and re-establish a mosaic of brackish and salt marsh along tidal pools. The slow recovery of marsh vegetation was exacerbated by Hurricane Sandy. Several new breaches resulted and existing breaches expanded. During development of the CCP/EIS, the Service consulted with Atkins to evaluate several restoration scenarios to restore the saltmarsh system. Atkins' modeling efforts examined current and potential future hydrodynamic and salinity conditions such as no restoration activities, leaving one breach open, repairing all dune breaches with no marsh restoration, and filling all dune breaches with tidal marsh restoration. The modeling process and results used to define the preferred plan of a beach breach repair and back barrier marsh platform and interior tidal circulation channels are described in Section 2.5. As a consequence of Alternative B's habitat protection and restoration measures, the refuge is expected to have increased resiliency and improved ecosystem function. Visitor services would be enhanced through a proposed expansion of access facilities and new trails for wildlife observation, photography, fishing, environmental education, and an expanded hunting program.

Alternative C: The habitat management measures proposed under this alternative were previously conducted on the refuge during most of its existence, but were stopped in recent years as a result of environmental changes, court decisions, and Service policy updates. Historic use of the refuge lands included cooperative farming and management of freshwater wetland impoundments. This alternative

would require the Service to partner with other natural resource agencies to conduct infrastructure and dune enhancements to re-establish freshwater impoundments. Remaining upland fields would again be managed for farming. Some public use programs would be expanded, similar to those in Alternative B. This alternative was rejected as it does not address or reduce the causative factors that are exacerbating flooding within the refuge. The refuge's 4,000 acres of impoundments would remain vulnerable to SLR due to their position immediately behind the coastal sand barrier. This alternative would be extremely difficult, costly and most likely, unsustainable long-term.

2.5 Selected Plan

The goal of the selected plan is to manage the biological diversity, integrity, and environmental health of both the wetlands and interior upland forested areas to sustain high quality habitats for migratory birds, fish, and resident wildlife. Habitats within the refuge are dependent upon a healthy and resilient beach/dune/marsh system. Implementation of the preferred alternative would assist in restoring the natural ecological value of the refuge's barrier island and marsh system, restore the natural hydrological function within the Management Units, and provide valuable ecosystem services such as storm surge flood protection. The selected plan was developed with careful consideration to marsh restoration science and the results of intensive local hydrodynamic modeling.

Much of the literature on beach and marsh restoration work comes from efforts in Louisiana. The loss of barrier islands there was attributed to an inadequate sediment supply and insufficient back barrier marsh platform upon which barrier islands can migrate landward in response to storms and SLR (McBride and Byrnes, 1997). Storm overwashes onto back barrier marshes may be critical for beach berm maintenance (Godrey, 1976; Dolan, 1972a; Leatherman, 1979; Goldsmith, 1985) by maintaining the necessary width and elevation as salt marshes expand and reduce in size. Without an adequate natural sediment supply due to anthropogenic manipulations within the system, sand replenishment practices serve to support natural function of the bay beach/back barrier marsh complex. Tyler and Zieman (1999) have shown that tidal creeks are an important component of any marsh restoration effort, and increased creek edge within the marsh increases the rate at which marshes mature. Restoration of these habitats focuses on restoring necessary elevations and hydroperiod for salt marsh plant species (*e.g*. *Spartina* spp.) and tidal creek flow to provide both the mechanism for sediment transport and the sites for the processes that affect marsh development.

The total length of Delaware Bay beach fronting Prime Hook NWR is approximately 49,000 linear feet. Not all of the entire length of beachfront is severely eroded. The State of Delaware's 10-Year Planning Report incorporates the developed part of Prime Hook Beach community in their beach nourishment program but none of the refuge's undeveloped shorefront. The area from the north end of Prime Hook Beach community, moving northward towards Fowler Beach Road and continuing northwest to Slaughter Beach Road has endured erosion and several beach breaches, most severely following Hurricane Sandy in 2012 (see Figures 2-1 through 2-6). The estimated quantity of sand needed to repair this breached area is approximately 1.1 million cubic yards.

The selected plan for the Prime Hook NWR is to restore beaches and marshes by closing shoreline breaches and constructing a marsh platform behind the beach barrier with tidal channels to restore more natural hydrologic circulation for saltmarsh species (*e.g. Spartina* spp.). Tidal influx will provide both a mechanism for sediment transport and should enhance the rate of marsh development. Studies have suggested that increasing the amount of creek edge in a tidal marsh will increase the rate at which created marshes mature (Tyler and Zieman, 1999). Atkins (2014a) used aerial photography (1956 to1968) to develop a design for marsh restoration that includes the creation of tidal creeks that follow historic tidal

creek patterns within the local geomorphology and water level elevations ascertained through the numerical model. Anticipated water levels and tidal flow velocities within the memory of the local geology should maintain the alignment of the circulation channels. Sustainability is a key feature of the Service's plan goals. Morris *et al*. (2002) concluded that as long as relative SLR does not exceed 3 to 20 mm/year, high marsh areas can sustain their elevation relative to water level while low marsh areas maintain or increase in elevation relative to water level. Estimates of SLR at the Lewes tide station (NOAA, 2009) are on the order of 3 to 3.5 mm/year.

While the CCP/EIS (2012) was being prepared, as well as after, habitat changes continued to occur in the refuge resulting in further breaching and flooding. Hurricane Sandy exacerbated the rapid inundation of saltwater that has killed freshwater vegetation, and with the persistence of a sediment deficit, due in part to decades of freshwater impoundment conditions in Units II and III, the refuge has continued to experience elevation subsidence and other biochemical changes in the absence of any significant sediment deposition (USFWS, 2012).

Working directly with the Service, Atkins used a hydrodynamic circulation model (2014) to examine marsh restoration scenarios. These design plans were evaluated for modifications to the breaches, roadways, and water control structures to examine their effect on water levels and salinities within the refuge for long-term average conditions as well as storm conditions. Atkins used the Delt 3D hydrodynamic model, which was designed using detailed local bathymetry and topography data, and was calibrated against extensive local water level and salinity data. The major parameters used in the model to evaluate restoration options were water depth/volume and salinity. The 6-month model runs covered a spring tide/neap tide cycle.

Early iterations of the modeling evaluated breaches open (existing conditions), all breaches closed, and a scenario leaving just one breach open, based on discussions with wetland professionals and community partners. For each of these scenarios, the model also evaluated the removal of a portion of Fowler Beach Road and water control structures. The breaches were found to be the primary source of variation in water levels. Results demonstrated that with one breach open, water levels would be intermediate between the all breaches open and all breaches closed scenarios, but would still result in open water across the marsh surface (Figure 2-7). Leaving one breach open would pose a number of additional challenges to the project. Given the degraded state of the back-barrier marsh, an open breach would be unstable and would be vulnerable to widening and deepening. Furthermore, the marsh surface could continue to be submerged, hindering the survival of planted *Spartina* and the natural re-establishment of marsh vegetation in the interior of the impoundment.

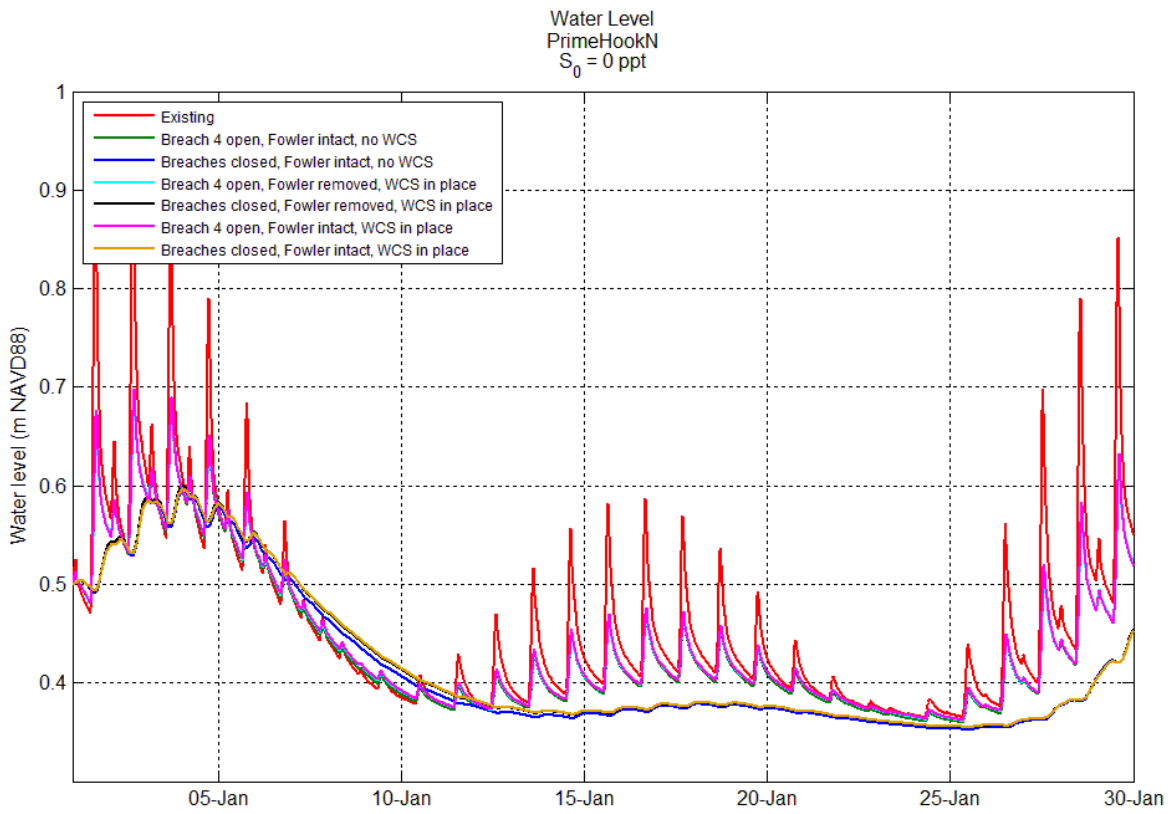


Figure 2-7: Water levels for seven initial restoration scenarios which combined various alterations to breaches, Fowlers Beach Road, and water control structures (Atkins, 2014a).

Early modeling results also demonstrated that with all breaches closed, tidal exchange and sufficient salinity would reach the impoundment system through Slaughter Canal and the Broadkill River (Figure 2-8). From a modeled starting salinity of 0 ppt, the salinity climbed over several months to reach levels of 20 ppt, without any additional modifications to the wetland hydrology. Closing all breaches would avoid the challenges associated with leaving one breach open, as discussed above. Thus, subsequent modeling runs evaluated only variations of the "closed breaches" scenario to determine whether additional restoration strategies could further improve tidal circulation and conditions to support re-establishment of marsh vegetation.

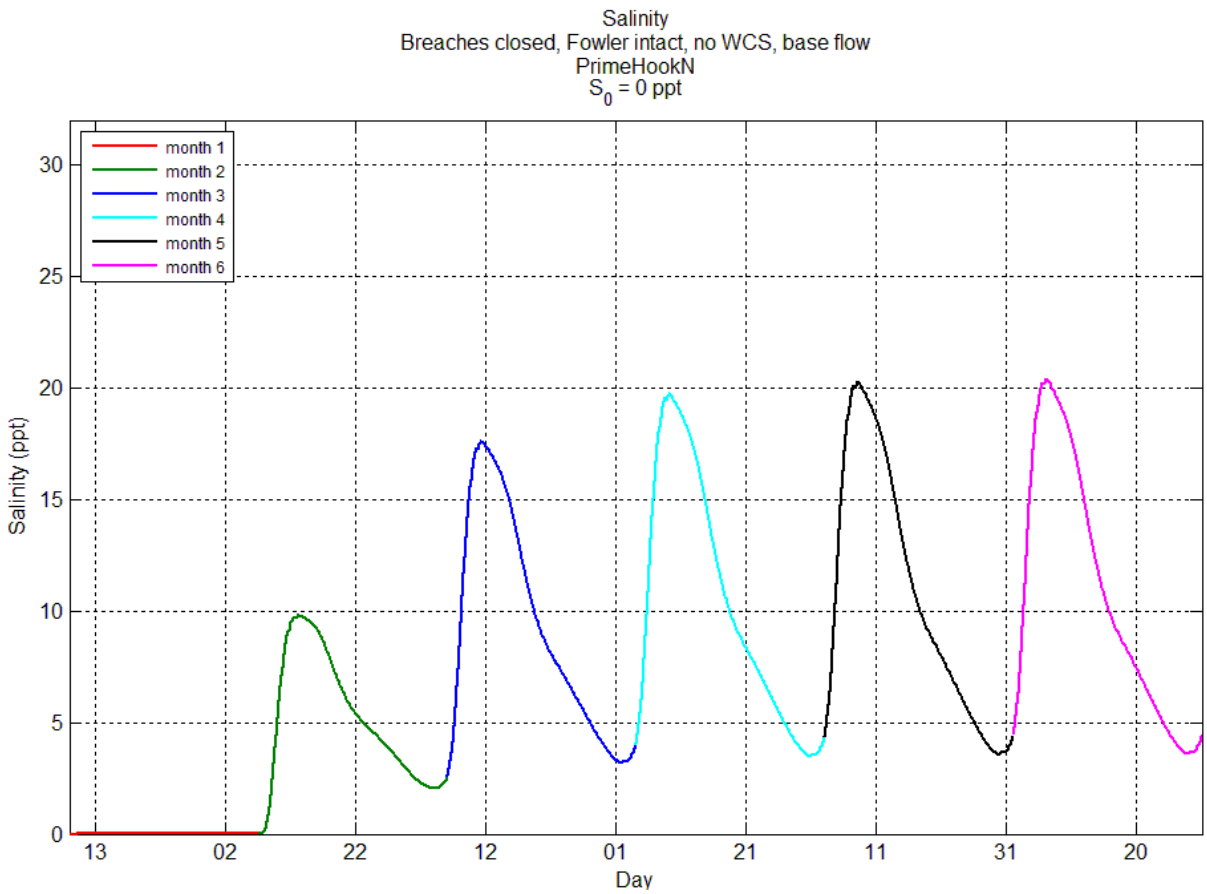


Figure 2-8: Salinity over 6 months of model runs for a restoration scenario with all breaches closed, Fowler Beach Road intact, water control structures removed, and an initial salinity of 0 ppt (Atkins, 2014a).

During subsequent modeling, three scenarios were evaluated, including all breaches closed with no further restoration; breaches closed with a main conveyance channel connecting Slaughter Canal (and thus, Mispillion Inlet) to the Broadkill River and Roosevelt Inlet (via Prime Hook Creek and Petersfield Ditch) to allow for greater exchange between the refuge and Delaware Bay; and a scenario with all breaches closed, a main conveyance channel, and secondary finger channels (Atkins, 2014a). Modeled results for each scenario were mapped to show the distribution of water level and salinity throughout the impoundment complex. The model results and maps demonstrated that adding a main channel increased tidal exchange, in turn, lowered water levels within the refuge, and increased the average and maximum salinities within all four Management Units. Additionally, the secondary finger channels proposed distributed saltwater to a larger area within the refuge than the main channel alone (Figure 2-9).

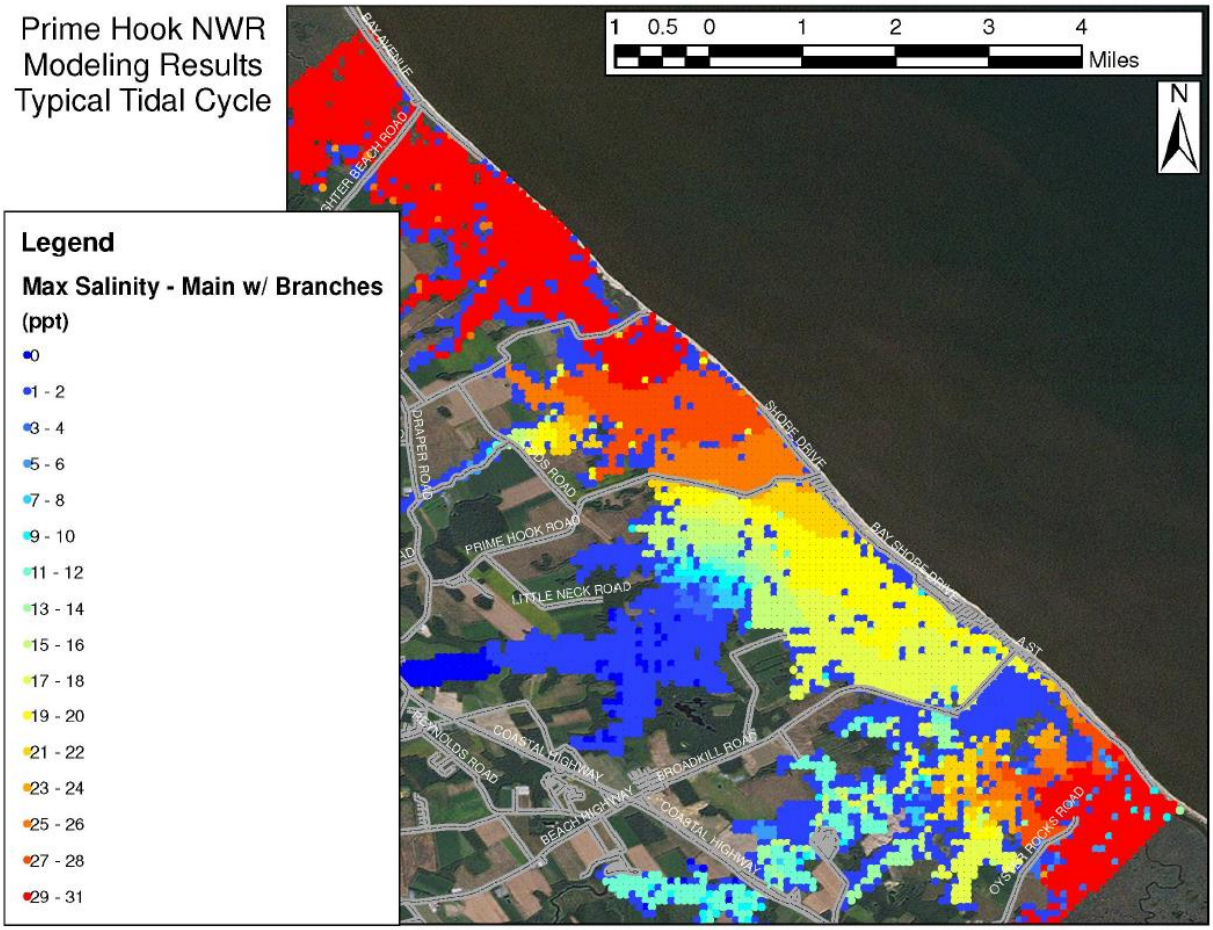


Figure 2-9: Salinity levels throughout the Refuge wetlands under the Selected Plan, with all breaches closed and the addition of both a main conveyance channel and secondary finger channels (Atkins, 2014a).

The selected plan of a beach breach repair, back barrier marsh platform design, and creation of a tidal channel network in the marsh interior, is supported by the modeling. A *Spartina*-dominated marsh community appears to be capable of being sustained by the salt water delivered through Slaughter Canal. The preferred plan includes removal of the water control structure and partial removal of Fowler Beach Road (approximately 1,800 feet at the easternmost end).

It has been suggested by others that additional land acquisition be considered as part of the refuge's selected restoration plan. However, as stated above, land acquisition and expansion of the refuge's acquisition boundary are actions that were considered but eliminated during the CCP/EIS process, and such purchases would not meet the refuge's restoration goals. Additionally, the appropriation for the current project is the Hurricane Sandy Disaster Relief Supplemental Appropriation Act of 2013, Public Law 113-2. This appropriation specifically precludes the use of these funds for land acquisition.

The biological and habitat objectives of the selected plan, and the refuge management strategies, are to restore the biological integrity and diversity of habitat to conserve migratory bird populations, improve forested habitats for interior bird conservation and endangered species, increase bird diversity, and

minimize mosquito development through the introduction of tidal water circulation within the wetlands. The Service recognizes that the selected plan must meet these objectives in the face of physical forces that are changing the climatic environment that in turn force changes in plant and animal distributions. The preferred plan outlines a proactive habitat management approach in response to these changing coastal conditions. In addition, a comprehensive monitoring program has been developed to track the response of vegetation communities, fish, and wildlife, as well as to monitor changes in physical parameters such as water level, salinity, water quality, sediment concentrations, and marsh elevation. The monitoring program will provide data evaluating success and for applying adaptive management during the restoration project and beyond.

2.5.1 Beach Berm and Dune Restoration

The selected plan involves the placement of beachfill sand obtained from a nearshore borrow area via hydraulic pipeline dredging on approximately 6,375 linear feet of shoreline within the refuge's Management Unit II. The estimated quantity of material need for the beachfill is 1.1 million cubic yards (cy). The sand will be placed on the beach to create a dune and beach berm of uniform cross section (Figures 2-10 and 2-11). The seaward beach berm will be approximately 220 feet wide and the landward berm will be approximately 70 feet wide at elevation +7.2 North American Vertical Datum (NAVD 88) with a dune at an elevation of +9.8 feet NAVD 88. The dune will be 40 feet wide at its crest and incorporate 7.5 acres of planted dune grasses across the surface of the dune. The dune shall have a total of 11,885 linear feet of sand fence running parallel to the dune along both the seaward and landward toes. The beach restoration entails restoring the natural conditions that would occur in the project area. It entails placement of sand along the shoreline to extend the width of the beach berm and dune to increase the level of protection against storm events. The beach berm is the primary feature and provides additional beach width to dissipate wave energy. The dune is the secondary feature that provides additional height to prevent storm surge overtopping. Dune vegetation provides additional protection against erosion forces of wind and waves. American beach grass (*Ammophila breviligulata*) is a natural dune plant species and planted along the top (dune crest) and down both the landward and seaward face slopes to increase stability of the dune. The landward facing berm slope may encroach on less than 0.5-acre of *Spartina* saltmarsh where it transitions to the wetland platform.

2.5.2 Wetland Restoration

The proposed wetland restoration entails the establishment of a marsh platform approximately 400 feet wide tying into the landward edge of the beach berm and running the length of the beachfill dune with a slope of 75:1 to elevation +1.6 NAVD 88 and then transitioning to a slope of 100:1 until tying into existing ground (see Figures 2-10 and 2-11). The material to construct the marsh platform will be pumped from the borrow area. The length of the back barrier marsh platform backing the beach berm is 6,375 linear feet with a 70-foot wide platform crest (landward berm at elevation +7.2 NAVD 88). The back barrier marsh platform is designed to incorporate the existing shoals which have formed after the breaching occurred. Once sufficient elevations are established on the marsh platform with dredged material, *Spartina* spp. will be planted along approximately 60 acres of the marsh platform. Additionally, natural colonization of *Spartina* and other saltmarsh plants is expected to occur rapidly.

Adjacent and interior of the marsh platform, a combination of a main channel conveyance and offshoot finger conveyance channels will be excavated. The main conveyance channel (approximately 51 feet wide and -3.5 feet NAVD88 with a potential -0.5-foot NAVD88 overcut) will be begin at the southernmost end of Management Unit I at Fowler Beach Road traveling south through Management Units II and III and ending in the northernmost portion of Management Unit IV just south of Broadkill

Beach Road. Several finger conveyance channels (approximately 27 to 44 feet wide and -2.5 feet NAVD88 with a potential -0.5-foot NAVD88 overcut) will branch off of the main conveyance channel within the interior portions of Management Units II and III (Figure 2-12) to increase tidal circulation throughout the refuge marshes. Excavated material from these channels will be side-casted in 150-foot wide reaches to enhance habitat variability within the marsh with both high and low elevation areas (Figures 2-13 and 2-14). Side-casted material will not be placed on existing vegetation or within historic open water pools. It will be placed alternately on both sides of the channel, so as not to create long linear elevated levees that could restrict flow out of the channel onto the marsh platform. Side-casted material will be strategically placed in lower elevation regions to build up the marsh platform elevation. Approximately 113,739 linear feet of dredged channels will be excavated, side-casting approximately 575,000 to 675,000 cubic yards of material (126.9 acres in Unit II and 257.7 acres in Unit III). It is expected that the thin-layering and ensuing reduction in water levels will result in the establishment of 1,000 acres of vegetated tidal marsh. Approximately 1,800 linear feet of the easternmost section of Fowler Beach Road, separating Units I and II, will be removed to allow for additional *Spartina* colonization. No wetlands will be impacted at any of the designated staging areas.

2.5.3. Borrow Area

Three potential borrow areas identified for the proposed restoration at Prime Hook NWR are PHB-A (350 acres), PHB-B (845 acres) and PHB-C (600 acres) (Figure 2-15). For the Prime Hook NWR, Borrow area PHB-B is the preferred borrow area. It is the largest and located closest to the project site, thereby reducing pumping distance and associated operational costs. PHB-B supports low biodiversity, thereby minimizes biological impacts. Area PHB A and Area PHB-C are both located immediately south of Borrow Area PHB-B. Excavation in Borrow Area PHB-B is proposed to take place on the leeward (southwest to south) side of the shoal, which would greatly reduce the likelihood of wave transformations that have the potential to alter the rate or location of shoreline erosion.

The effects of Borrow Area PHB-B sediment excavation (to a depth of 5 feet below the bay bottom) on the potential for onshore wave transformation, during both normal seasonal and Hurricane Sandy conditions, were assessed using the Delft3D model. The model was used to evaluate the magnitude of potential changes that could result from excavation of all available surficial sand deposits within the borrow area (a total volume of 5.58 million cubic yards). It was determined that wave heights, wave energy, and the direction in the nearshore, and within the borrow area are minimally affected during normal seasonal conditions. During Hurricane Sandy in the nearshore, the maximum wave height is increased by less than 5 percent and the maximum energy transport is increased by less than 10 percent. In the borrow area, the wave height is increased by 20 percent or less (2014b).

The modeling revealed that the wave features at the shoreline adjacent to the borrow area are affected only to a small degree even for the maximum potential dredge cut. It should be noted that the modeling was done with a total excavation of 5.58 million cubic yards while the selected plan for the beach berm/dune construction only requires approximately 1.1 million cubic yards. Consequently, the actual dredge cut would have a smaller footprint than what was modeled, and the wave transformation analysis represents a worst-case scenario (Atkins, 2014b).

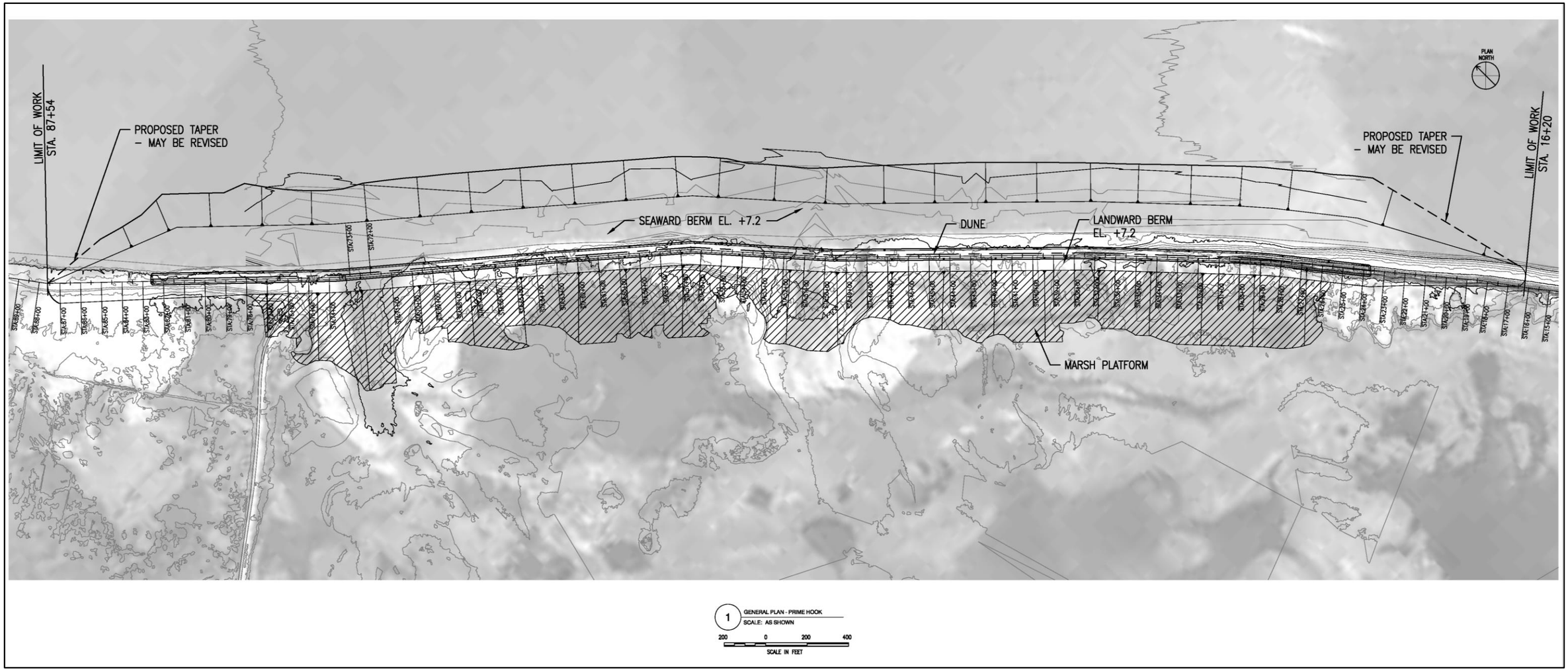


Figure 2-10: Plan view of beach berm/dune and back barrier marsh platform (60% design).

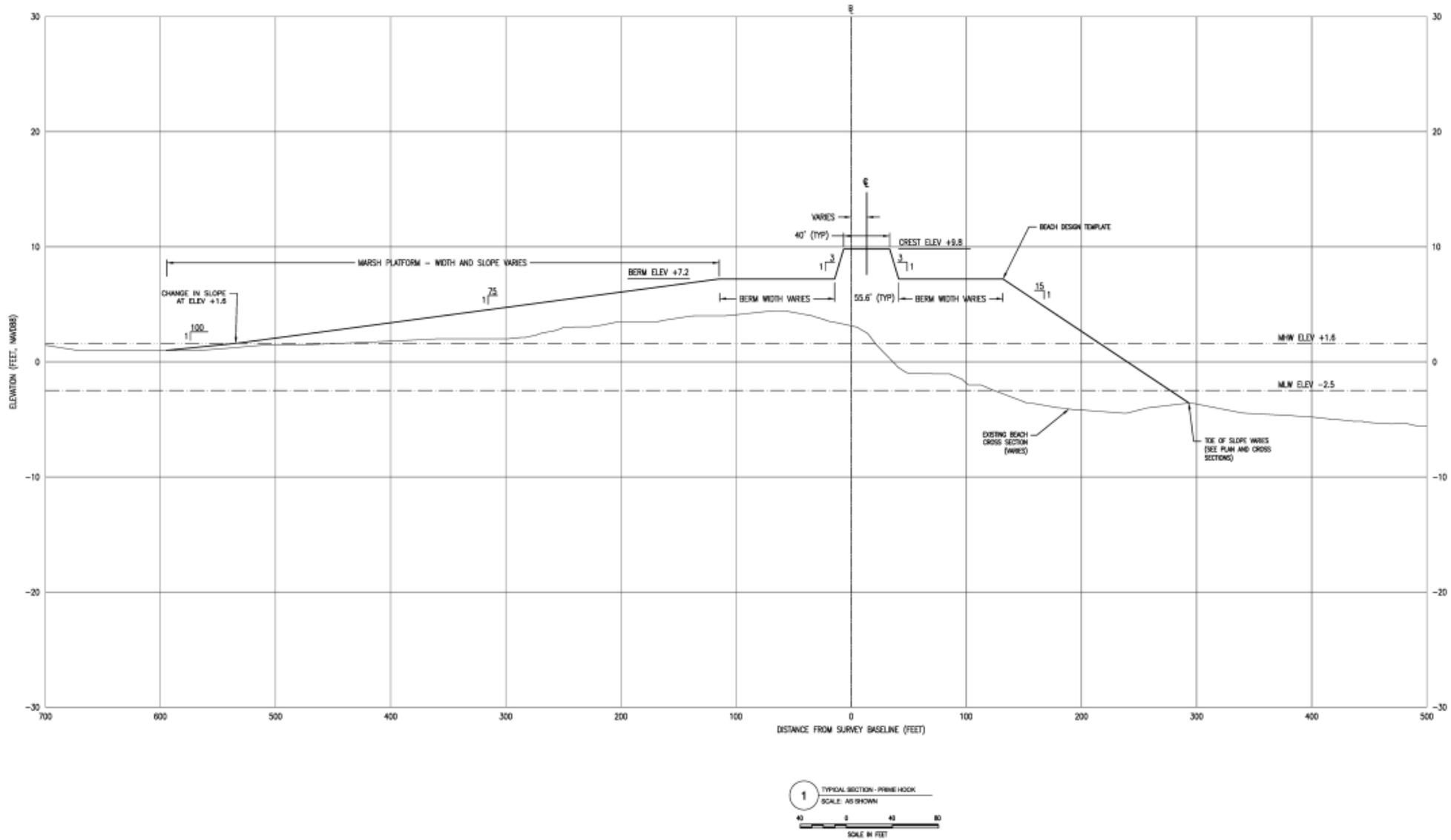


Figure 2-11: Cross-section of beach berm/dune and back barrier marsh platform (60% design).

PRIMEHOOK MARSH RESTORATION PROJECT					
ALIGNMENT	UNIT LOCATION	LINEAR LENGTH (FT)	WIDTH (FT)	MAX. DEPTH (FT)	DREDGE VOLUME (CY)
ALIGNMENT-CHANNEL A	UNIT II & III	26,500	40	-3.5	198,774
ALIGNMENT-CHANNEL B	UNIT II	10,627	40	-3.5	92,959
ALIGNMENT-CHANNEL C	UNIT II	7,872	20	-2.5	24,960
ALIGNMENT-CHANNEL D	UNIT II	2,161	20	-2.5	6,584
ALIGNMENT-CHANNEL E	UNIT II	742	20	-2.5	2,159
ALIGNMENT-CHANNEL F	UNIT II & III	10,657	20	-2.5	28,913
ALIGNMENT-CHANNEL G	UNIT II & III	3,156	20	-2.5	12,642
ALIGNMENT-CHANNEL H	UNIT II & III	3,167	20	-2.5	9,454
ALIGNMENT-CHANNEL I	UNIT III	15,738	20	-2.5	58,995
ALIGNMENT-CHANNEL J	UNIT III	4,426	40	-2.5	15,183
ALIGNMENT-CHANNEL K	UNIT III	3,470	40	-2.5	14,075
ALIGNMENT-CHANNEL L	UNIT III	3,827	40	-2.5	21,296
ALIGNMENT-CHANNEL M	UNIT III	4,412	40	-2.5	16,574
ALIGNMENT-CHANNEL N	UNIT III	2,653	20	-2.5	6,105
ALIGNMENT-CHANNEL O	UNIT III	11,033	20	-2.5	50,653
ALIGNMENT-CHANNEL P	UNIT III	1,523	20	-2.5	5,038
ALIGNMENT-CHANNEL Q	UNIT III	937	20	-2.5	3,131
ALIGNMENT-CHANNEL R	UNIT III	838	20	-2.5	2,790
TOTAL LINEAR LENGTH (FT)		113,739	TOTAL DREDGE VOLUME (CY)		570,285

VOLUMES PER CHANNEL

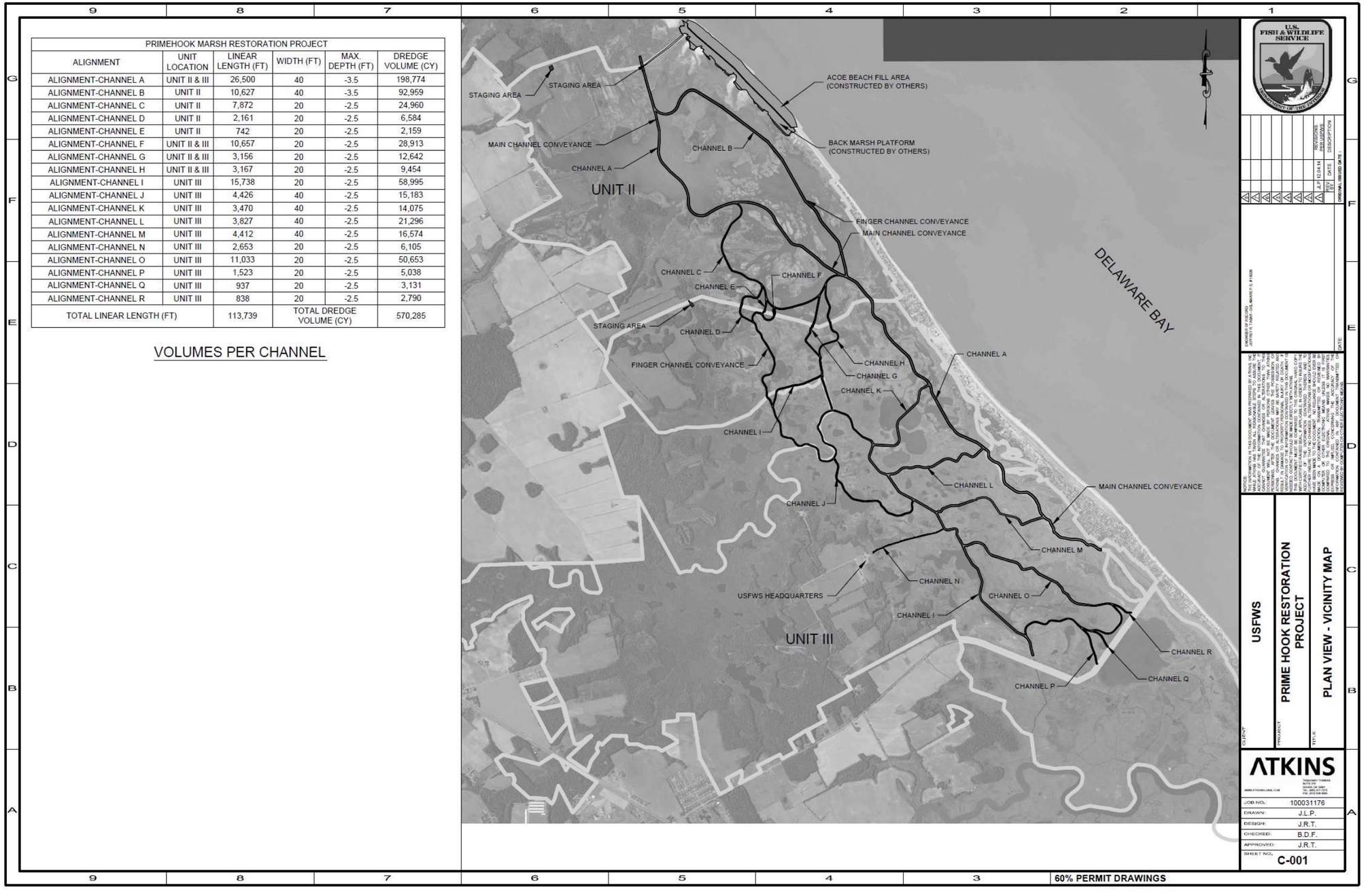
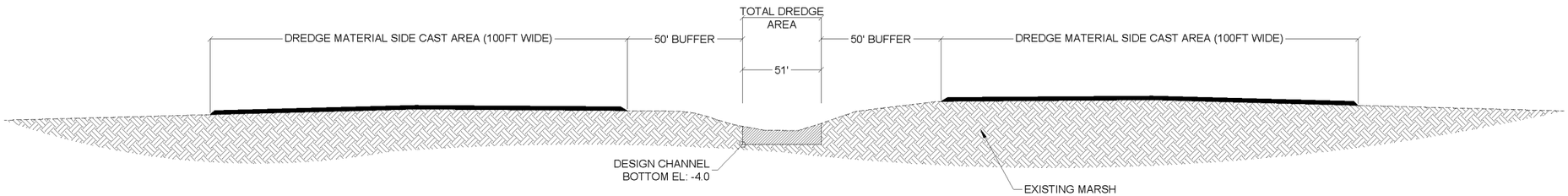
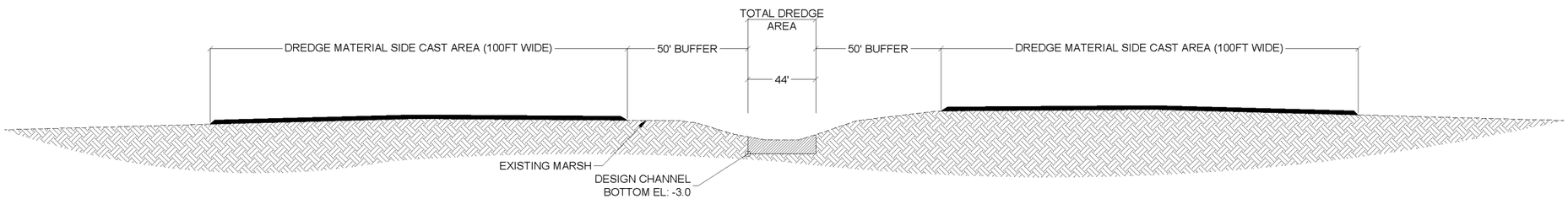


Figure 2-12: Plan view of interior marsh excavated channels (60% design).

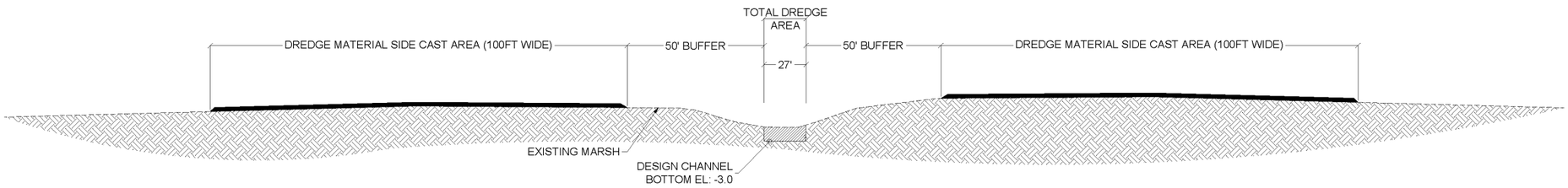
Figure 2-13: Close-up plan view of the interior marsh excavated channels sidecasting areas (60% design).



TYP 3: PRIMARY CONVEYANCE CHANNEL TYPICAL DETAIL



TYP 4: SECONDARY CONVEYANCE CHANNEL TYPICAL DETAIL



TYP 5: TERTIARY CONVEYANCE CHANNEL TYPICAL DETAIL

Figure 2-14: Cross section view of interior wetland excavated channels (60% design).

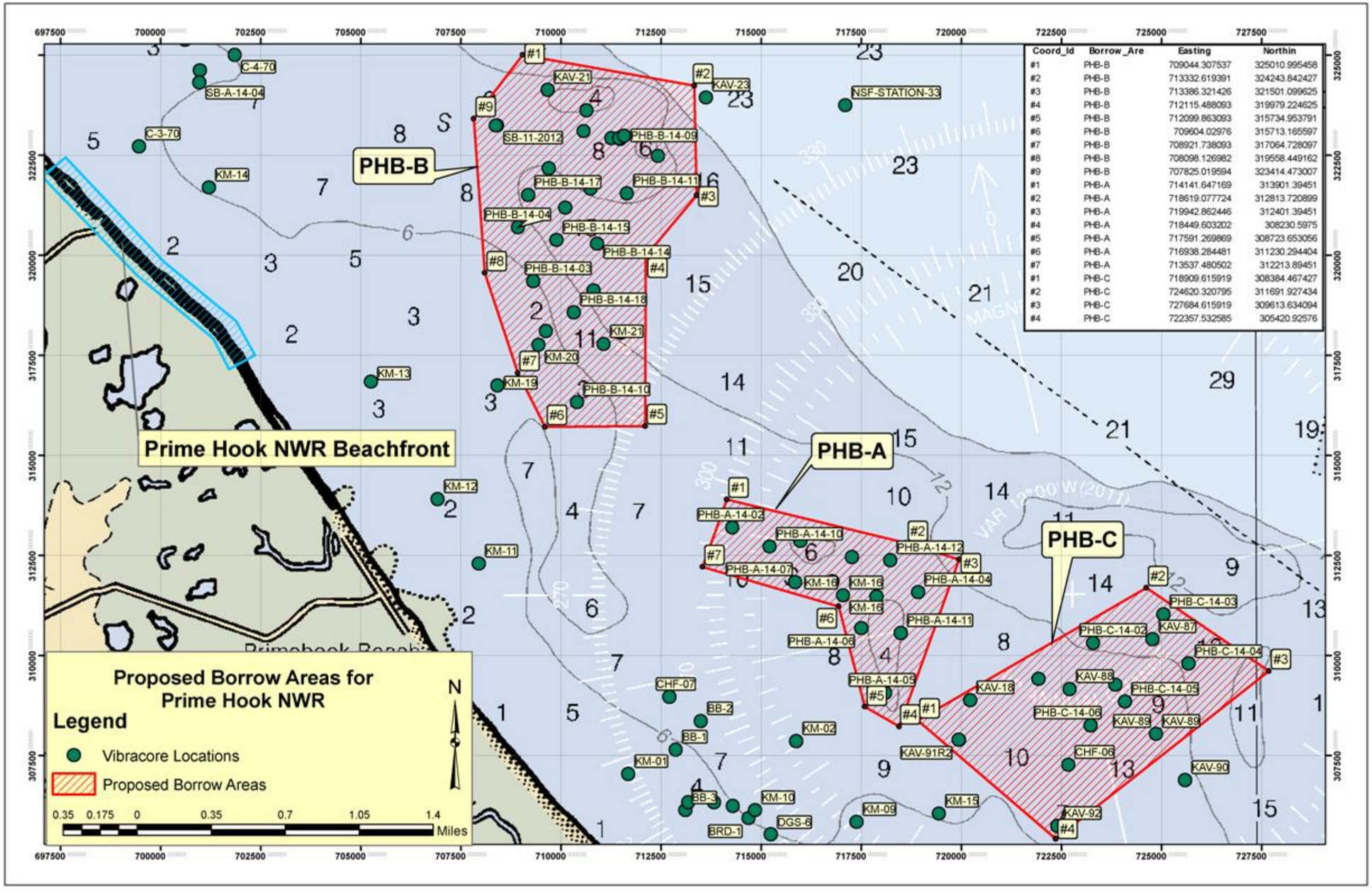


Figure 2-15: Borrow areas PHB-B, PHB-A, and PHB-C.

3.0 Affected Environment

The following provides a summary review of the physical and biological environment of the project area. More detailed descriptions of these environmental features are provided in chapter 3 of the CCP/EIS (2012) and incorporated by reference herein. Feature characteristics that have changed, or more information is now available since completion of the CCP/EIS (2012), are noted in Table 3-1.

Table 3-1. Status of Affected Resources

Resource	EA Sections	Significant Changes or New Information Since CCP/EIS, 2012	Notes
Geographic Setting	3.1; 4.1	Yes	Increased erosion and habitat loss
Geology	3.2; 4.2	No	Summarized
Surface Water	3.3; 4.3	Yes	Increased open water inundation
Beach and Intertidal Habitat	3.4; 4.4	Yes	Increased erosion and habitat loss
Wetlands/Vegetation	3.5; 4.5	Yes	Increased vegetation losses due to inundation
Marine Resources	3.6; 4.6	Yes	Updated information since CCP/EIS (2012)
Essential Fish Habitat	3.6.4; 4.6.4	Yes	Additional information since CCP/EIS (2012)
Wildlife	3.7; 4.7	No	Summarized
Threatened and Endangered Species	3.8; 4.8	No	Summarized
Climate/Sea Level Rise	3.9; 4.9	Yes	Updated information since CCP/EIS (2012)
Cultural Resources	3.10; 4.10	Yes	Updated information
Socioeconomic Environment	3.11; 4.11	Yes	Updated information
Air Quality	3.12; 4.12	Yes	Updated information
Noise	3.13; 4.13	Yes	Additional to CCP/EIS (2012)
Recreation	CCP/EIS (2012)	No	No further discussion
Public Use and Access	CCP/EIS (2012)	No	No further discussion

3.1 Geographic Setting

The Delaware Estuary is one of the most heavily used estuaries in the nation. The northern reaches support one of the world's greatest concentrations of heavy industry and the second largest oil refining and petrochemical centers in the U.S. About 70 percent of transported oil (over one billion barrels of crude and refined oil products) reaches the east coast of the U.S. through the Delaware Estuary by way of the ports of Philadelphia, Camden, Gloucester City, Salem, and Wilmington (PDE, 1996). Approximately 20 percent of the U.S. population lives within a 1 to 2 hour drive away from the Delaware Bay. It is a well-mixed estuary due to tidally dominant flow (Hauser, 2002) and characterized by wide, shallow, subtidal flats comprised primarily with coarse sands in the lower bay. The tidal reaches of the Delaware River and Delaware Bay have been included in the National Estuary Program, a partnership initiative authorized by Section 320 of the Clean Water Act designed to protect estuarine systems of national significance (DRBC, 2012).

Prime Hook NWR is located in Sussex County, Delaware within the Atlantic Coastal Plain Province, along the southwestern shore of lower Delaware Bay. The refuge's eastern boundary runs next to three beachfront communities: Slaughter beach, Prime Hook Beach, and Broadkill Beach, with some agricultural lands for corn, soybean, and poultry production. Four roads that bisect the refuge have altered the hydrology and other ecological processes within the refuge's wetland habitats. Two interior roads, Fowler Beach Road and Prime Hook Road have associated culverts and water control structures located in Units II, III and IV and directly affect the refuge's water level management capabilities (see Figure 2-1).

3.2 Geology and Hydrology

The refuge is located in the Coastal Plain Province and consists of unconsolidated sediments that have accumulated over the past 150 million years as a result of erosion of the Appalachian Mountains and marine sediment deposition. Eroded water-borne sands, silts, and clays have been deposited, followed by marine sediment shifting during periods of alternating sea encroachment and retreat. Alternating advancing and retreating continental glaciers and dramatic sea level changes capped sediments with fluvial sands and gravels during the Pleistocene 1.8 million years ago. During the past 10,000 years, rising sea levels have filled coastal valleys with sediment, forming extensive tidal marshes.

Rising sea levels have caused shorelines to retreat 3 to 4 miles over the past 5,000 years, systematically drowning the ancient Delaware River valley and gradually transforming the narrow river into the wide Delaware Bay as it is currently shaped. Delaware Bay's shoreline is migrating in geologic time in a landward direction. Subsidence (or sinking) is occurring while sea levels continue to rise relative to the land. Additionally, erosion and redistribution of sediments in the active coastal littoral zone is shifting the shoreline in a landward direction (Kraft *et al*., 1976). Headlands along the bayshore of the refuge are being buried and/or eroded as the sand barrier migrates landward and upward across marshes by overwash as sea levels rise (Maurmeyer, 1978). Subsiding land elevations within the drowned freshwater impoundments are not able to keep pace with SLR within the refuge through sediment accretion without their saltmarsh vegetation.

Between 1834 and 1954, the bayshore from Slaughter Beach to Roosevelt Inlet has retreated at a rate of 1 to 25 feet per year (Coxe, 2013)(Figure 3-1). The refuge shoreline has lost approximately 1,100 feet or roughly a loss of 10 feet per year on average (B. Scarborough, Delaware Coastal Programs (DCP), pers. comm.). Most shoreline erosion of the Delaware Bay is caused by waves generated by local winds. The

highest elevation within the refuge is 15 feet mean sea level, and the majority of the lands lie below the 9-foot contour.

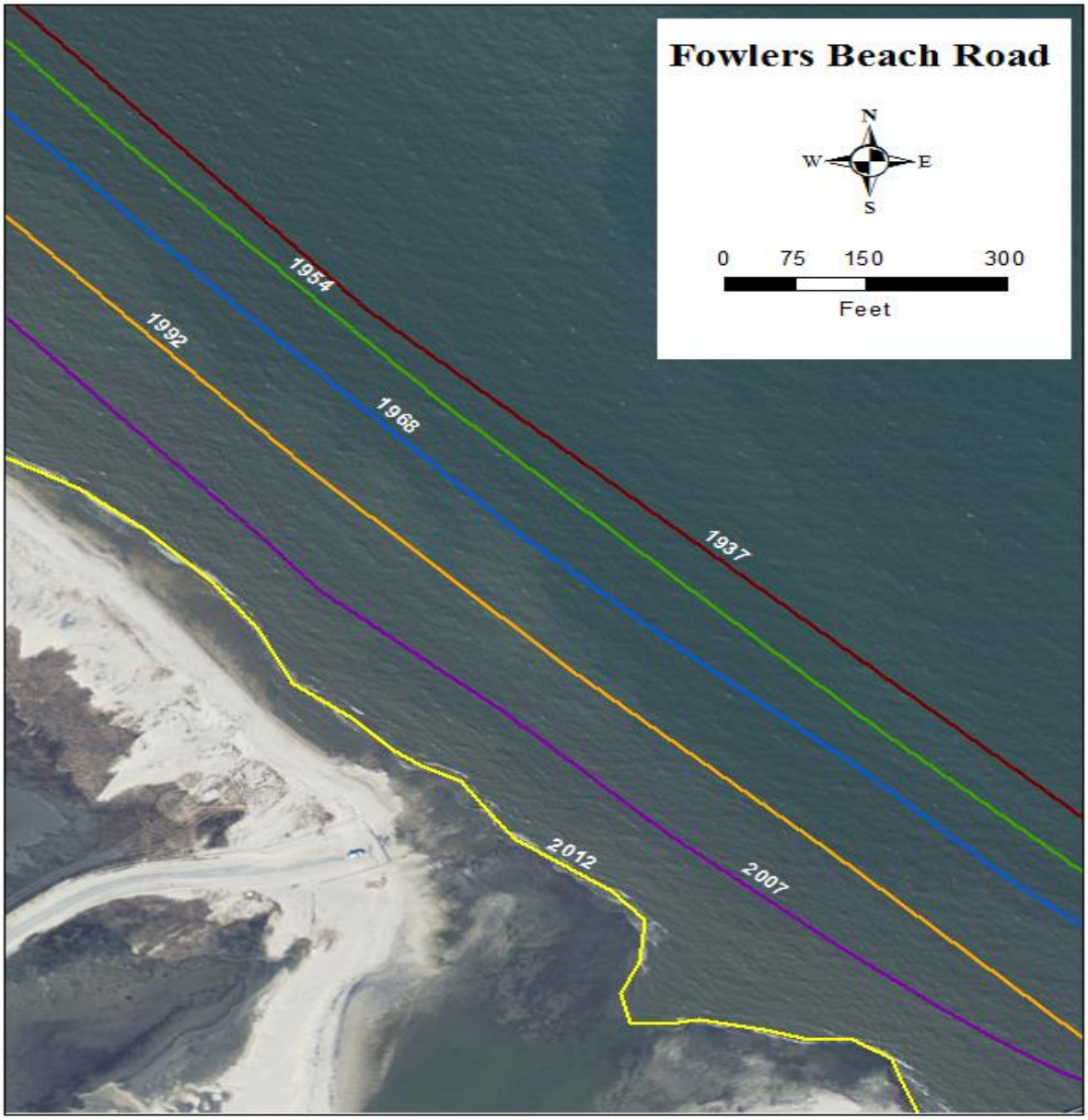


Figure 3-1: Shoreline Movement between 1937 and 2012 at Fowler Beach Road. From 1937 to 1954: 50 feet; from 1954 to 1968: 116 feet; from 1968 to 1992: 215 feet; from 1992 to 2007: 307 feet; and from 2007-2012: 410 feet.

3.3 Surface Water Quality

The refuge is influenced by three watersheds: Mispillion River, Cedar Creek, and Broadkill River. The coastal geology of the area, bay morphology, and bathymetry all influence and vary the periodicity and magnitude of water levels within the refuge constantly. Daily water level changes as a result of astronomical tides for both Mispillion River and Roosevelt Inlet vary from -0.7 to 5.8 feet. Adding in wind energy, water level changes can deviate from predicted tidal levels. The salinity within the lower Delaware Bay is predominantly polyhaline (18 to 30 ppt) with more fresh to near-fresh (mesohaline) waters in interior areas, fed by freshwater steams, rain, and groundwater. Water level and salinity within the refuge have been collected since 2010 by an automated YSI Sondes Monitoring Network at 7 locations within Management Units II and III (DCP and USFWS). Over time, salinities within Units II and III have increased (Figures 3-2 and 3-3). Sample locations nearer to tidal exchanges with the bay exhibit higher salinities (PHNWR, Annual Habitat Work Plan, 2014).

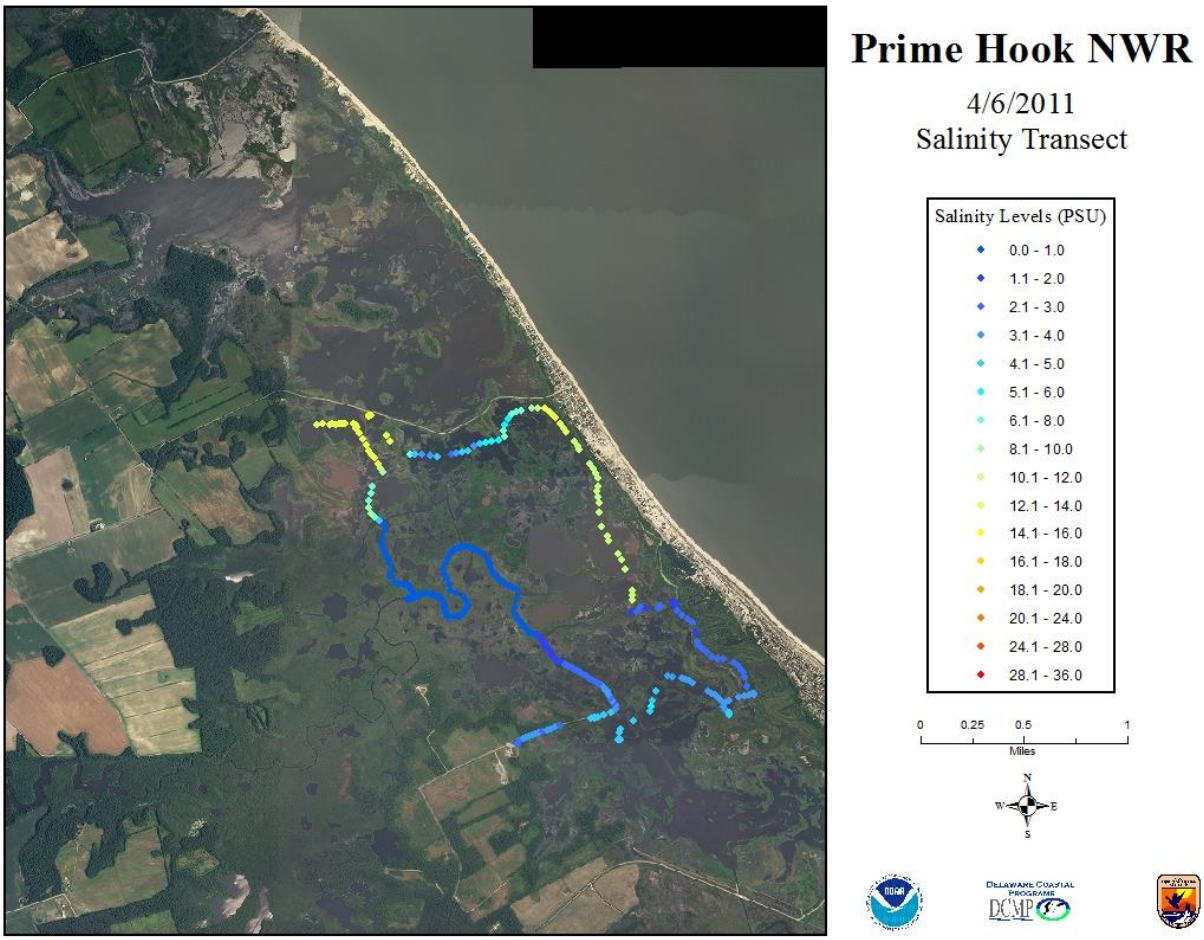


Figure 3-2: Salinity transect measurements taken April 6, 2011 (DCP)

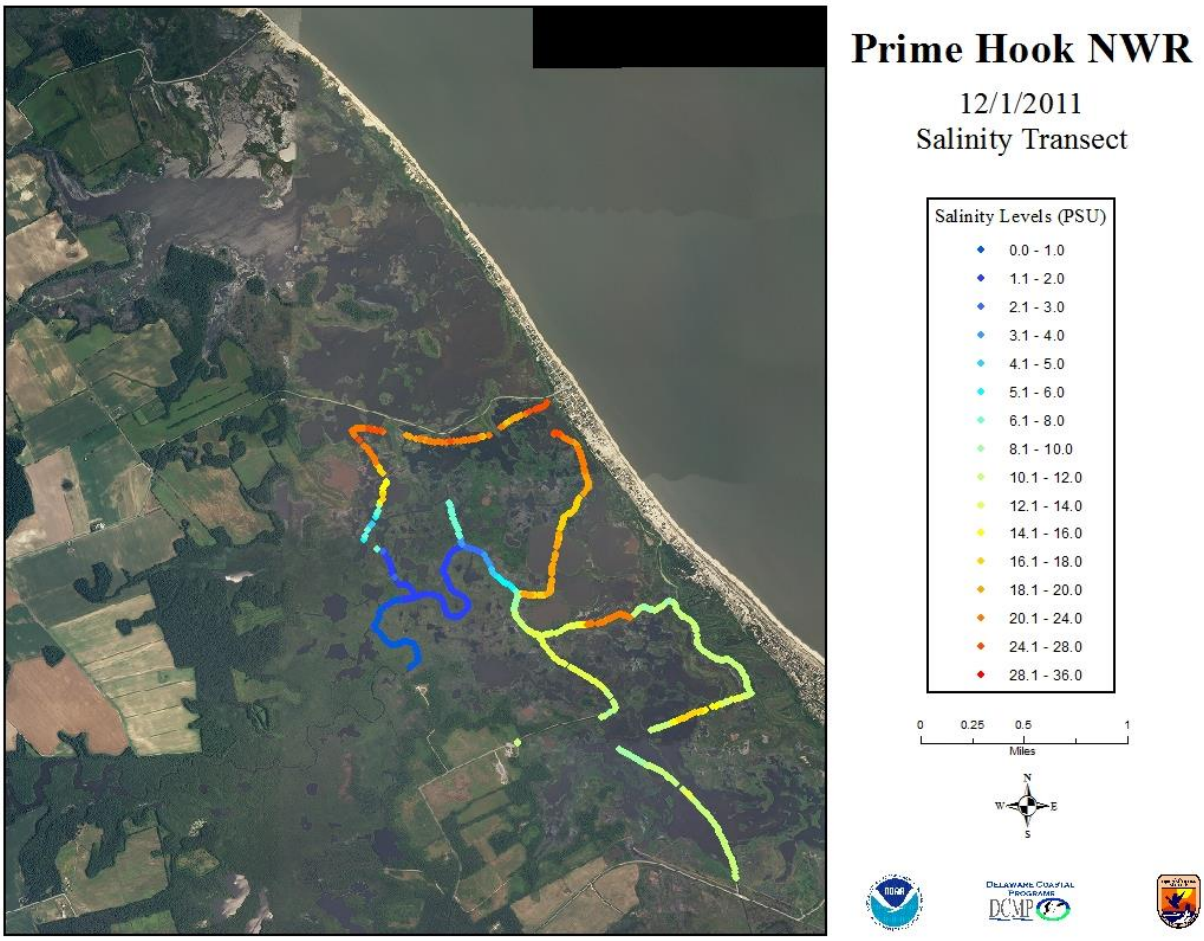
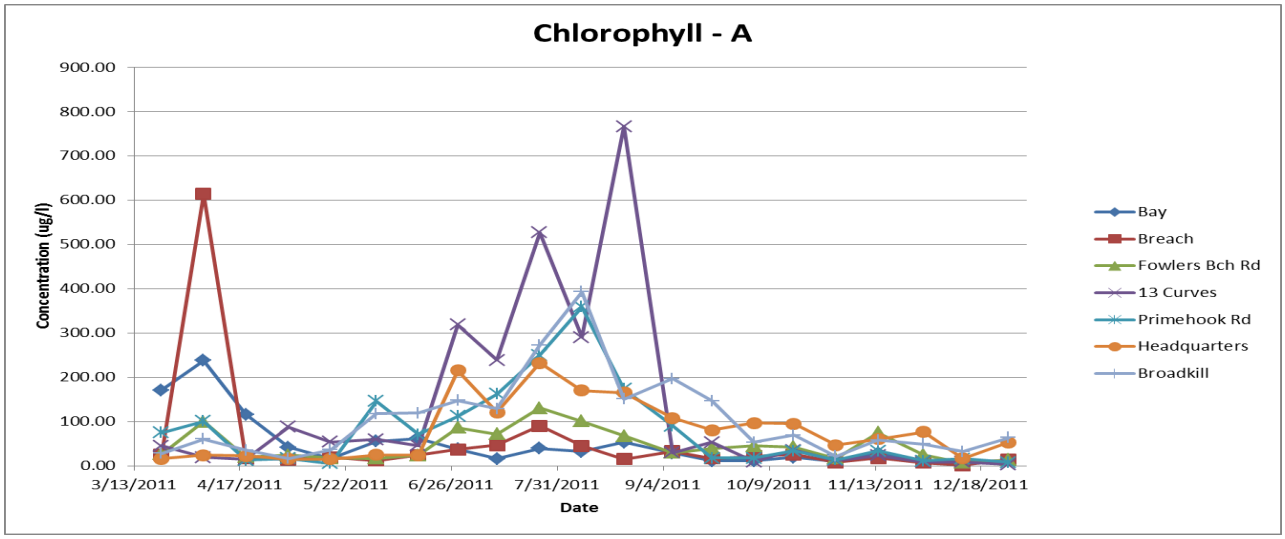


Figure 3-3: Salinity transect measurements taken December 1, 2011 (DCP, 2011)

The refuge staff, in collaboration with the Delaware Coastal Programs, have conducted semi-monthly nutrient monitoring in the refuge since 2010. One parameter measured, chlorophyll-a , is the green pigment in plants that permits photosynthesis to occur, which in turn requires active respiration by algae and phytoplankton in the waters of the refuge. Algae produce oxygen during the daylight hours but use up oxygen during the night and when they die and decay. Algal blooms typically occur in the warm season when nutrients in the water are more abundant. Too much algal growth results in depleted oxygen levels and die-off. Monitoring chlorophyll levels tracks algal growth. Surface waters high in chlorophyll indicate high nutrient levels, typically an indicator of pollution. Figure 3-4 shows chlorophyll-a levels measurements taken during 2011 at seven locations within the refuge; the majority of which were rated poor for the water quality index (Environmental Protection Agency National Coastal Condition Guidelines for the Northeast Coast).

The 2008 State of Delaware Combined Watershed Assessment Report indicates that the majority of the State's water resources are suffering from poor water quality. Pathologic indicators (bacteria) are the most widespread pollutants, but nutrients and toxics pose additional impairment. Sources cited for poor water quality include nonpoint agricultural runoff, septic system failures, animal feed lots operations,

urban runoff, and municipal and industrial point sources. The Delmarva Peninsula is one of the largest poultry production areas in the U.S.. Delaware has over 900 chicken farms, with the majority in Sussex County. Within a 6-mile radius of the refuge, there are about 19 poultry farms, with four immediately adjacent to the refuge (DDA, 2007).



Date	Location						
	Bay	Breach	Fowlers Bch Rd	13 Curves	Primehook Rd	Headquarters	Broadkill
3/22/2011	171.22	24.43	26.33	45.16	74.35	15.96	27.76
4/5/2011	237.78	614.04	100.05	19.37	100.93	23.84	60.18
4/19/2011	115.99	17.60	19.81	13.91	12.52	22.36	35.34
5/3/2011	41.30	14.01	23.77	87.52	16.43	15.19	16.98
5/17/2011	15.47	18.98	17.45	53.39	5.33	15.14	36.15
6/1/2011	55.76	11.89	16.27	59.63	145.85	24.35	117.86
6/15/2011	61.85	24.01	23.91	45.88	70.66	24.17	118.94
6/28/2011	37.57	37.19	86.33	318.52	112.00	215.24	147.79
7/11/2011	16.17	46.82	71.90	238.38	161.72	120.82	128.64
7/25/2011	39.24	90.18	130.29	526.50	250.10	231.80	272.80
8/8/2011	31.90	44.87	100.27	290.40	358.55	170.11	392.49
8/22/2011	53.30	15.34	67.65	766.50	173.64	165.30	150.39
9/7/2011	28.97	32.84	29.54	29.48	90.10	107.49	196.67
9/20/2011	11.34	16.50	39.08	53.07	17.26	80.04	146.74
10/4/2011	11.03	21.38	45.06	9.18	17.69	96.53	52.60
10/17/2011	19.04	25.56	42.59	35.31	33.41	95.16	69.17
10/31/2011	9.51	7.82	16.87	11.51	13.19	46.11	21.26
11/14/2011	29.05	17.38	75.12	22.98	33.89	60.32	57.78
11/29/2011	8.91	7.03	24.64	8.48	11.24	76.05	48.72
12/12/2011	8.80	1.62	7.18	8.84	16.20	16.39	31.67
12/27/2011	11.25	14.07	13.47	3.29	8.04	52.92	63.65

EPA National Coastal Condition Guidelines for Northeast Coast

CHLA	<5 ug/L Good
	5-20 ug/L Fair
	>20 ug/L Poor

Figure 3-4: Chlorophyll-a concentrations at seven sampling locations within Prime Hook National Wildlife Refuge during 2011 (USFWS/DCP).

The Delaware River Basin Commission (DRBC) prepared a 305 (b) report (DRBC, 2012) that assessed water quality of the Delaware River and Bay between October 1, 2006 through September 30, 2011 in support of various designated uses in accordance with Section 305 (b) of the Clean Water Act. DRBC obtains water quality data from many sources, including the U.S. EPA STOrage and RETrieval (STORET) database, the U.S. Geological Survey (USGS) National Water Information System (NWIS)

database, and the National Oceanographic and Atmospheric Administration (NOAA) Physical Oceanographic Real-Time System (PORTS) database. DRBC designates separate reaches of the estuary as assessment units (AUs) and are defined by river mile. Delaware Bay is in the DRBC's assessment unit (AU) 6 (river mile 48.2 at the north end to the bay mouth at 0.0 river mile). Designated water uses for AU 6 include aquatic life, recreation, and fish and shellfish consumption.

Elevated levels of some toxic substances have been detected in sediments, the water column, and in organism tissues within the Delaware Estuary, although contaminants are more prevalent in the upper reaches of the estuary (*i.e.* Delaware River) than have been found in the lower Delaware Bay. For the lower Delaware Bay, DRBC (2012) found water quality in this portion of the estuary to be generally characterized as fair to good. DRBC has noted some exceedances of acute marine stream quality objective for copper and in fish tissue, methyl mercury in Zone 6. The presence of contaminants in some areas have prompted DNREC to post fish consumption advisories from the Chesapeake and Delaware (C&D) Canal down to the mouth of the Delaware Bay for striped bass, channel and white catfish, American eel, white perch, and bluefish (DNREC, 2010b).

3.4 Beach and Intertidal Habitat

In typical undisturbed beach profiles along the lower Delaware Bay coast, a primary dune has flora that is adapted to the harsh conditions of strong winds, salt spray, and shifting sands. The dominant plant on bay beach dunes is American beachgrass (*Ammophila breviligulata*). It is a rapid colonizer that can spread by horizontal rhizomes, and also has fibrous roots that can descend to depths of 3 feet to reach moisture. Beachgrass is instrumental in the development of dune stability, which opens up the dune to further colonization with more species like seaside goldenrod (*Solidago sempervirens*), sea-rocket (*Cakile edentula*), and beach cocklebur (*Xanthium echinatum*).

Further landward of a healthy dune/salt marsh complex, beach vegetation tends to be more stable resulting from the protection provided by the primary dunes. The increased stability also allows an increase in plant species diversity. Some of the plant species in this zone include: beach heather (*Hudsonia tomentosa*), coastal panic grass (*Panicum amarum*), saltmeadow hay (*Spartina patens*), broom sedge (*Andropogon virginicus*), beach plum (*Pnmus maritima*), seabeach evening primrose (*Oenothera humifisa*), sand spur (*Cenchrus tribuloides*), seaside spurge (*Ephorbia polygonifolia*), joint-weed (*Polygonella articulata*), slender-leaved goldenrod (*Solidago tenuifolia*), and prickly pear (*Opuntia humifusa*).

Currently, approximately 15,000 linear feet of beach fronting the refuge is badly eroded. Management Units II and III, the areas containing former freshwater impoundments, have the most degraded wetlands and the lowest accretion rates of the State's bayshore habitats (Figure 3-5). Presently, elevations in many area of Units II and III are just at or below the optimal growth range for *Spartina alterniflora*, with a mass majority of the land cover as open water and tidal mudflat. Unit I, where no freshwater impoundments were constructed, contains higher elevations and higher historic accretion rates (keeping pace with or exceeding SLR).

In the marine intertidal zone organic inputs are derived primarily from the bay waters in the form of beach wrack, which is composed of drying seaweed, tidal marsh plant debris, decaying marine animals, and miscellaneous debris that are washed up and deposited on the beach. The beach wrack provides a cooler, moist microhabitat suitable to crustaceans such as the amphipods *Orchestia* spp. and *Talorchestia* spp., which in turn provides prey items for various foraging bird species and mammals. Under current

conditions of low elevation, a sediment deficient bay source, and insufficient back barrier salt marsh vegetation, beach sand is continually eroded by tidal flooding and exposing the underlying peat mat.

Figure 3-5: Eroded wetlands at Prime Hook National Wildlife Refuge, March 2014.

3.5 Vegetation and Land Cover

The refuge possesses vegetation typical of the Atlantic coastal plain dune, marsh, grasslands and upland forest. Vegetation surveys are conducted seasonally to assess vegetation for wetland-dependent migratory birds (PHNWR, Annual Habitat Work Plan, 2014). Habitat names follow the National Vegetation Classification System (NVCS) while land cover types are named by the Coastal and Marine Ecological Classification Standard (CMES). Field observations and aerial photo-interpretation are used to assess historical changes over the past 75 years (Figure 3-6). Thirty-eight vegetation communities and 17 land covers were found on the refuge within Management Units I, II, and III (Coxe, 2013). This most recent mapping showed that Northeastern Old Field (904 acres) was the largest vegetation community cover-type on the refuge, followed by North Atlantic Low Salt Marsh (805 acres). However, non-vegetated land covers (*e.g*. beach, open water, and mudflat), most notably mesohaline and polyhaline open water, comprise the most acres (1,447 and 1,091 acres, respectively).

Maps were assessed in 2012 after Hurricane Irene, but prior to Superstorm Sandy, to evaluate habitat changes of predominant vegetative communities (PHNWR, 2014). Dune grassland has demonstrated landward migration to the west as more cover-type has been converted to polyhaline open water. Former saltmarsh has become overwash flats. Loss of beachgrass-panicgrass on dunes and shoreline erosion has

resulted in substantial changes over the most recent documented 10-year period (2002 to 2012) relative to slower vegetative changes that occurred during the previous 65-year interval (1937 to 2002). Species on dunes include salt meadow cordgrass (*Spartina patens*) and three-square (*Schoenoplectus pungens*). As a result of beach breaches, 5 acres in Unit I in 1937 have been reduced to 1 acre, and in Unit II, 3 acres that occurred in 1937 to 2002 no longer exist.

The refuge contained freshwater impoundments between 1982 to 2008 and consisted primarily of plant species that varied season to season and year to year based on weather, rainfall patterns and water level management. Species included wild rice (*Zizania palustris*), cattail (*Typha* spp.), and pickerelweed (*Pontederia* spp.). Units II and III began to lose emergent freshwater marsh vegetation due to beach breaches in 2006, due to saltwater intrusion. By 2012, 1,000 acres had converted to polyhaline open water and tidal mudflat. In Unit III 1,200 acres of emergent freshwater marsh had become mesohaline open water and reed tidal marsh.

Red Maple-Seaside Alder Woodland. The upper reaches of Prime Hook Creek within Unit III possessed a red maple-seaside alder woodland community that was just beginning to develop in 1937. Red maple (*Acer rubrum*) dominates and seaside alder (*Alnus maritime*) is rare in the State as well as globally. Common understory shrubs included sweet pepperbush (*Clethra alnifolia*) and southern bayberry (*Morella cerifera*). After breach formations in Unit II caused more saline waters to enter Unit III, the seaside alder, and to a lesser extent, the red maple populations began to decline.

Twig-Rush Peat Mat. In Unit III there are several peat bog communities dominated by twig-rush (Cladium mariscoides) with pink based yellow-eyed grass (*Xyris difformis*) and State-rare species including the Virginia meadow beauty (*Rhexia Virginia*), sessile leaved bugleweed (*Lycopus amplectens*), and small-fruited tick seed (*Bidens mitis*). Twenty-one State-rare wetland plants were identified within this vegetative community within Unit III. In 1937 there were 117 acres of this vegetative community but has steadily declined since then: 23 acres in 2002 down to 19 acres in 2012 (PHNWR, 2014).

Marine Nearshore Polyhaline Water. Water ranging in salinities 18 to 30 ppt did not occur within the refuge boundaries in 1937 but saltwater intrusion has since occurred with the westward transgression of the bay shoreline. Approximately 36 acres within Management Units I and II have been created since 1937.

Estuarine Coastal Polyhaline Water. This cover type results from tidal influx (18 to 30 ppt) but did not occur in Units II or III until after 2007, now covering 1,007 acres, mostly in Unit II.

Estuarine Coastal Mesohaline Water. Salinities ranging between 5 and 18 ppt, this cover type accounts for 1,446 acres in Units II and III.

Sabellaria Reef. This cover type consists of mounded aggregations of tubeworm reef along the intertidal shoreline. By 2012, this cover-type included 0.1-acre in Unit II but after Superstorm Sandy, the *Sabellaria* reef aggregates were broken up and no longer exist.

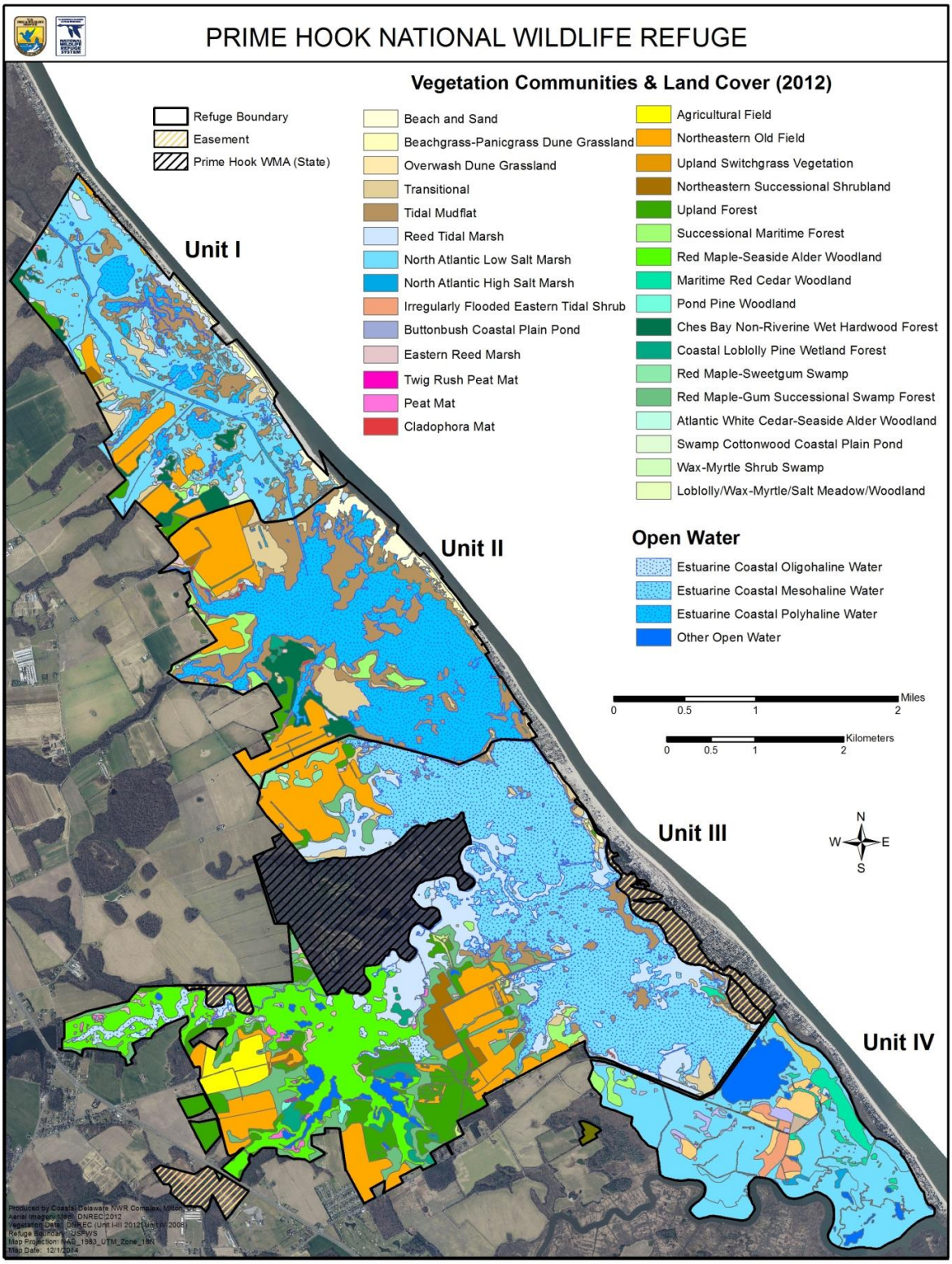


Figure 3-6: National Vegetation Classification System Map of Prime Hook NWR (2012).

Predominant plants within Prime Hook NWR wetlands are as follows: *Spartina patens, Spartina alterniflora, Phagmites australis, Iva frutescens, Spartina cynosuroides, Typha spp., Panicum virgatum, Hisbiscus palustris*. Nonwetland flora includes sedges (Cyperaceae), asters (Asteraceae), and grasses (Poaceae). The majority of refuge upland plants are perennial broadleaf herbs, trees, and shrubs. For more detailed information on plant species refer to chapter 3 of the CCP/EIS (2012). For further description of transitional land covers see Coxe, 2013.

Vegetative Communities and Land Cover

Management Unit I totals 1,624.9 acres, of which 1,504.7 are natural and 120.2 acres are anthropomorphic communities. This Management Unit receives tidal, brackish water from Slaughter Creek, which developed the *Spartina* low salt marsh, the largest vegetative cover type.

Management Unit II totals 1,997.5 acres and consisted previously of an impounded, nontidal freshwater system until the recent breaches from storms after 2008 caused tidal saltwater flooding, killing most of the freshwater vegetation represented in the NVCS mapping from 2005. Freshwater input if from Slaughter Creek from the west. Natural communities total 1,681.8 acres and 315.7 acres are anthropogenic communities (*i.e.* open fields and shrubs, lawns, and roads). The largest cover type is a generic marsh and shallow water habitat. The February/March 2010 algal bloom (*Cladophora*) marked the first time a nuisance algal bloom occurred on the refuge. *Cladophora* itself does not present a risk to human health but an excess of decaying algae can promote bacteria growth and indicates a stressed ecosystem.

Management Unit III is the largest of the four units, comprising 4,431.0 acres. Like Unit II, it was previously managed as a nontidal freshwater system. Natural communities cover 3,822.6 acres while 608.4 acres are anthropogenic areas. Generic marsh of both freshwater and brackish wetland species comprise the largest cover, along with open water. Prime Hook Creek flows west to east and roughly divides this unit into northern and southern halves. Unit III supports three vegetation communities that are currently known in Delaware only in the refuge: twig rush peat mat, pond pine woodland, and red maple-seaside alder woodland.

Management Unit IV is the smallest of the units with a total area of 1,176.4 acres, of which 1,111 acres consist of natural communities and 65.3 acres are anthropogenic areas. Unit IV receives tidal and brackish input from the Broadkill River and as a result, the largest natural community in the unit is *Spartina* low marsh. It also has a generic marsh area within the impounded portion.

Of the 426 plant taxa listed on the refuge inventory, 45 are nonnative, of which 10 are considered to be invasive. These include spotted knapweed (*Centaurea maculosa*), Canada thistle (*Cirsium arvense*), kudzu (*Pueraria* spp.), mile-a-minute (*Persicaria perfoliata*), Japanese honeysuckle (*Lonicera japonica*), river seedbox (*Ludwigia alternifolia*), Japanese stilt-grass (*Microstegium vimineum*), reed canary grass (*Phalaris arundinacea*), common reed (*Phragmites australis*), and multiflora rose (*Rosa multiflora*).

Phragmites control has been a major concern and activity on the refuge since the 1960s. *Phragmites* has expanded by 34 percent to cover 3,000 acres. Beginning in the 1980s, the herbicide glyphosate was field-tested by spraying on dense stands of *Phragmites* at the refuge and some prescribed burning. A second large-scale *Phragmites* control project was undertaken 20 years later. The spreading of *Phragmites* is often attributed to anthropomorphic manipulations of the water table through ditch digging and impounding. It is anticipated that the re-establishment of tidal saltwater flushing through the refuge will greatly reduce the expansive stands of the invasive Common reed.

3.6 Marine Resources

3.6.1 Placement Site and Borrow Area Sediments

Placement Area. Prior to the creation of the two freshwater impoundments in Units II and III in 1988, a barrier dune system separated the inland salt marsh from the Delaware Bay. The natural dune system was a discontinuous, low mound and ridge system interspersed with overwash areas that moved location with storms. Beginning in 1991, the duneline was overwashed a breached a number of times up to the present, creating expansive overwash and continuous inlets and flooding. The State of Delaware has conducted some dune repair work since that time by bulldozing sand from the overwash fan eastward to heighten the dunes (USFWS, 2010). More recently however, the increasing frequency of flooding events has resulted in substantial sand losses, exposing underlying peat from remnant marshes during low tide. These storm events have caused coastal flooding of refuge lands, public roads, and adjacent private properties, as well as erosion and repositioning of the refuge shoreline. With inadequate substrate elevations and tidal flushing, minimal re-vegetation has occurred.

The USACE conducted a beach sampling program at the refuge beach placement site. Sediment samples were obtained from five survey lines along the beachfront (PHGS-1 through PHGS-5) extending from the north end of the refuge south towards Prime Hook Beach and included the collection of three samples along each survey line: (1) along the existing dune, (2) the mid-beach (midway between the dune and the bay), and (3) near the surf. The beach sampling consisted of a surface sample approximately 0 to1-foot below ground surface from each location (Figure 3-7).

Beach sediments along the existing dunes consisted of light brown/tan to light and dark gray, poorly sorted, fine to medium sands, with trace amounts of coarse sand and fine gravel. The material collected along the mid-beach area consisted of tan and light/dark grey, fine to medium sand. Some silt was also encountered from the mid-beach sample along survey line PHGS-2. The material collected along the surf line consisted of light brown/tan to light grey, fine to coarse, sand with varying amounts of fine gravel. The gravel was present in trace amounts in samples PHGS-2 and PHGS-3 and increased to a sand and fine gravel in samples PHGS-4 and PHGS-5. The material present in PHGS-1 consisted of light gray sand, with some dark gray clay. The beach material samples were analyzed for sediment characteristics using the Automated Coastal Engineering System (ACES) computer program.

The samples were composted along survey lines and then along sample locations (dune, mid-beach, and surf). The geotechnical analysis of the beach samples and the subsequent compositing provided the following characteristic parameters: mean grain size = 0.593 phi (0.663 mm) and a standard deviation = 1.543 phi (0.343 mm). Table 3-2 provides a summary of the ACES material evaluation.

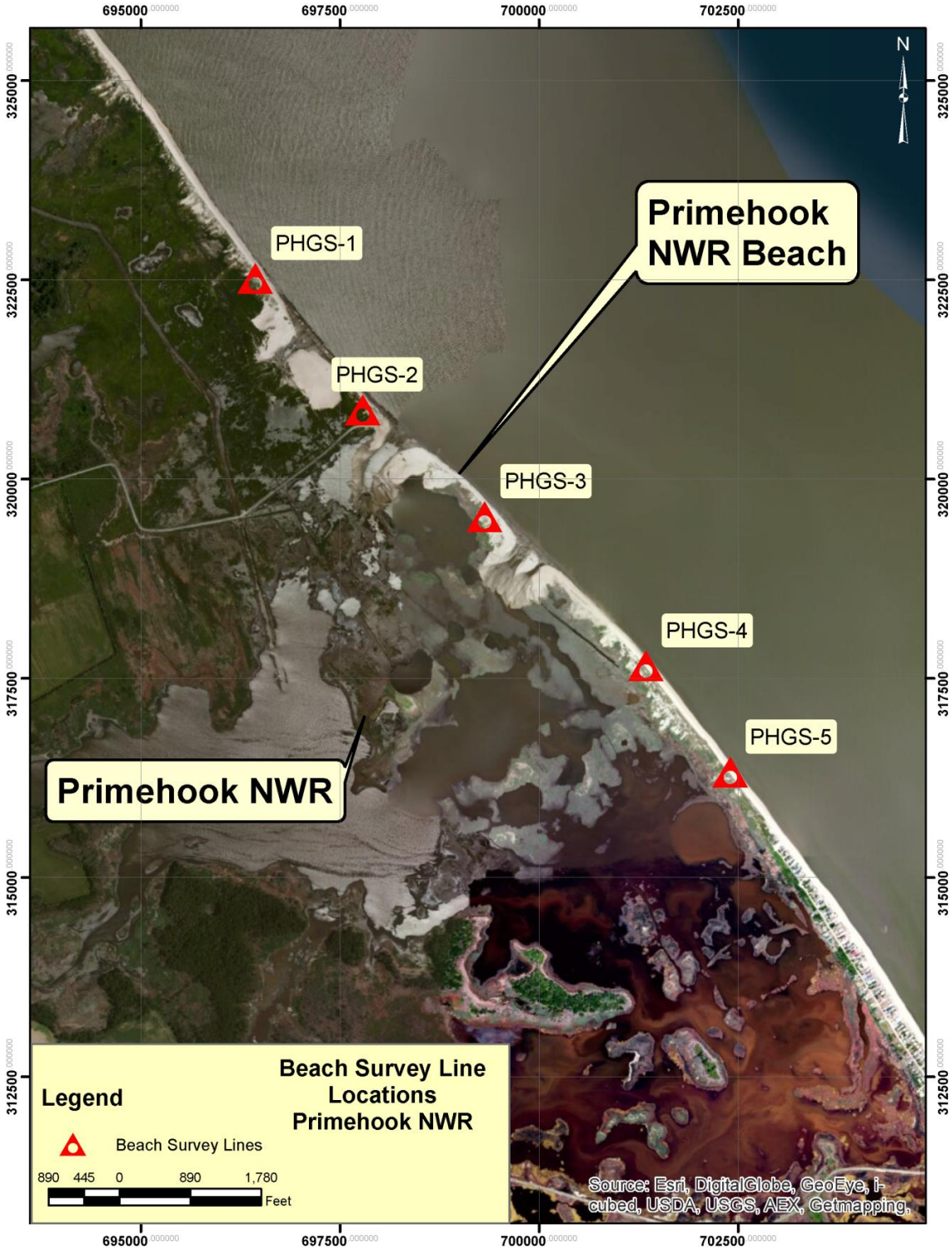


Figure 3-7: Location of five beach sediment survey sample lines PHGS-1-PHGS-5.

Table 3-2: ACES Placement Site and Borrow Area Characterization.

Sample ID	Sample Elevation (ft)	Mean Grain Size (phi)	Mean Grain Size (mm)	Standard Deviation (phi)	Standard Deviation (mm)	Description
PHGS-1	0-1	0.837	0.560	1.317	0.401	Fine to medium sand
PHGS-2	0-1	0.611	0.655	1.567	0.338	Fine to medium sand, some fine gravel
PHGS-3	0-1	1.118	0.461	1.053	0.482	Fineto medium sand
PHGS-4	0-1	0.440	0.737	1.400	0.379	Fine to medium sand
PHGS-5	0-1	0.484	0.715	1.318	0.401	Fine to medium sand
Dune	0-1	1.153	0.450	1.340	0.395	Fine to medium sand
Mid-Beach	0-1	1.000	0.500	0.833	0.561	Fine to medium sand
Surf	0-1	-0.281	1.215	1.819	0.283	Fine to medium sand, some fine gravel
PH Beach Composite*	0-1	**0.593**	**0.663**	**1.543**	**0.343**	Medium/fine, sand, some fine gravel
PHB-A (5-foot cut)	-9.3 to -19.9	1.023	0.492	1.213	0.431	Fine to medium sand
PHB-A (bottom cut)	-19.3 to -28.9	0.730	0.603	1.681	0.312	Fine to medium sand
PHB-A (Composite)		0.871	0.547	1.517	0.349	Fine to medium sand
PHB-B (5 foot cut)	-8.2 to -24.8	**1.360**	**0.390**	**1.492**	**0.356**	Fine to medium sand
PHB-B (bottom cut)	-18.2 to -33.5	1.035	0.488	1.237	0.424	Fine to medium sand
PHB-B (Composite)		1.267	0.416	1.362	0.389	Fine to medium sand
PHB-C (5-foot cut)	-14.9 to -24.1	1.185	0.440	1.040	0.486	Fine to medium sand
PHB-C (bottom cut)	-24.9 to -37.3	0.840	0.559	1.309	0.404	Fine to medium sand
PHB-C (Composite)		0.873	0.546	1.275	0.413	Fine to medium sand

Borrow Areas. Ocean Surveys (2013) conducted a marine geophysical investigation for DNREC that included benthic mapping and seabed/subbottom surveys in the lower Delaware Bay. The seabed survey was verified with physical samples that ranged from predominantly fine to medium sand. Three potential borrow areas have been identified for the project within the areas identified as having predominant sand (Figure 3-8). Vibracoring data was collected by Gehagan and Bryant (2014) for DNREC to locate beach quality sand to fulfill nourishment needs for seven bay beaches under DNREC's 10-Year Management Plan (DNREC & PBS&J, 2010): Pickering Beach, Kitts Hummock Beach, Bowers Beach, South Bowers Beach, Slaughter Beach, Prime Hook Beach, and Broadkill Beach.

Gehagan and Bryant (2014) analyzed and compiled existing Compressed High Intensity Radar Pulse (CHIRP) sub bottom data, Roxann seabed classification data, and historic core boring data. Single beam bathymetric data was collected to identify potential sand shoals and refine volume calculations of available sand deposits. Results from 50 vibracoring and sediment analyses revealed major quantities of beach compatible sands reside in the shoals offshore of the Prime Hook and Slaughter Beach areas. The shoal materials consist of medium to coarse grained sands and reside in surficial layers ranging from 12 to 20 feet thick. Combined, these potential borrow areas are approximately 4,500 to 11,500 feet offshore and contain up to 20 million cubic yards of beach compatible sands.

PHB-A. Vibracore samples collected from borrow area PHB-A indicated that the material present consists of fine to medium sand, ranging in color from a brownish yellow to a dark gray. The thickness of the sand within borrow area PHB-A ranged from approximately 10 to 20 feet. The dredge template for PHB-A would include the upper 5 feet of sand from the entire borrow area, and provide for approximately 2.8 million cubic yards (mcy) of surficial sands. The total volume of surficial sands from PHB-A has been estimated to be approximately 5.6 mcy.

PHB-B. Vibracore samples collected from borrow area PHB-B indicated that the material present consists of fine to medium sand, ranging in color from a brownish yellow to a dark gray with some silt and clay material within the center of the borrow area. The thickness of the sand, within borrow area PHB-B ranged from approximately 10 to 20 feet. The dredge template for PHB-B would include the upper 5 feet of sand from portions of borrow area. The available volume of surficial sands would be approximately 5.58 mcy.

PHB-C. Vibracore samples collected from borrow area PHB-C indicated that the material present consists of medium sand, ranging in color from a yellow to a dark gray. The thickness of the sand was approximately 20 feet throughout the site. The dredge template for PHB-C would include the upper 5 feet of sand from the entire borrow area, and provide approximately 4.8 mcy of surficial sands. The total volume of surficial sands from PHB-C has been estimated to be approximately 19.3 mcy.

A review of each of the three borrow areas, PHB-A, PHB-B and PHB-C, suggests that PHB-B is the most appropriate source of material for the Prime Hook NWR beach replenishment project. The distances of PHB-B to the refuge placement area ranges from 1.5 to 2.3 miles and is the closest of the three proposed borrow areas. Both PHB-A and PHB-C are greater than 3.9 miles from the refuge. The closer proximity of PHB-B to the placement site greatly reduces the costs associated with the transport of the material through the dredge pipe, as a longer distance of piping necessitates booster pumps to effectively transport the dredged material. The material present within PHB-B, which consists of fine to medium sands, and some areas with fine grained material (silts and clays), will provide suitable materials for both the beach front dune and berm, as well as the marsh platform.

The Nature Conservancy created an eco-regional assessment for the marine environment between the Bay of Fundy to Cape Hatteras (http://nature.org/namera/). This assessment characterizes the nearshore zone, including the location of all three identified borrow areas for the refuge as mid-position to high flats and depressions in shallow to moderate depths with fine to coarse sand. Anderson *et al*. (2010) mapped major physical habitats of the Delaware Bay seafloor for depth, sediment type, topography, and salinity in relationship to organism composition. They observed that salinity and sediment type were the important drivers of the composition of benthic communities.

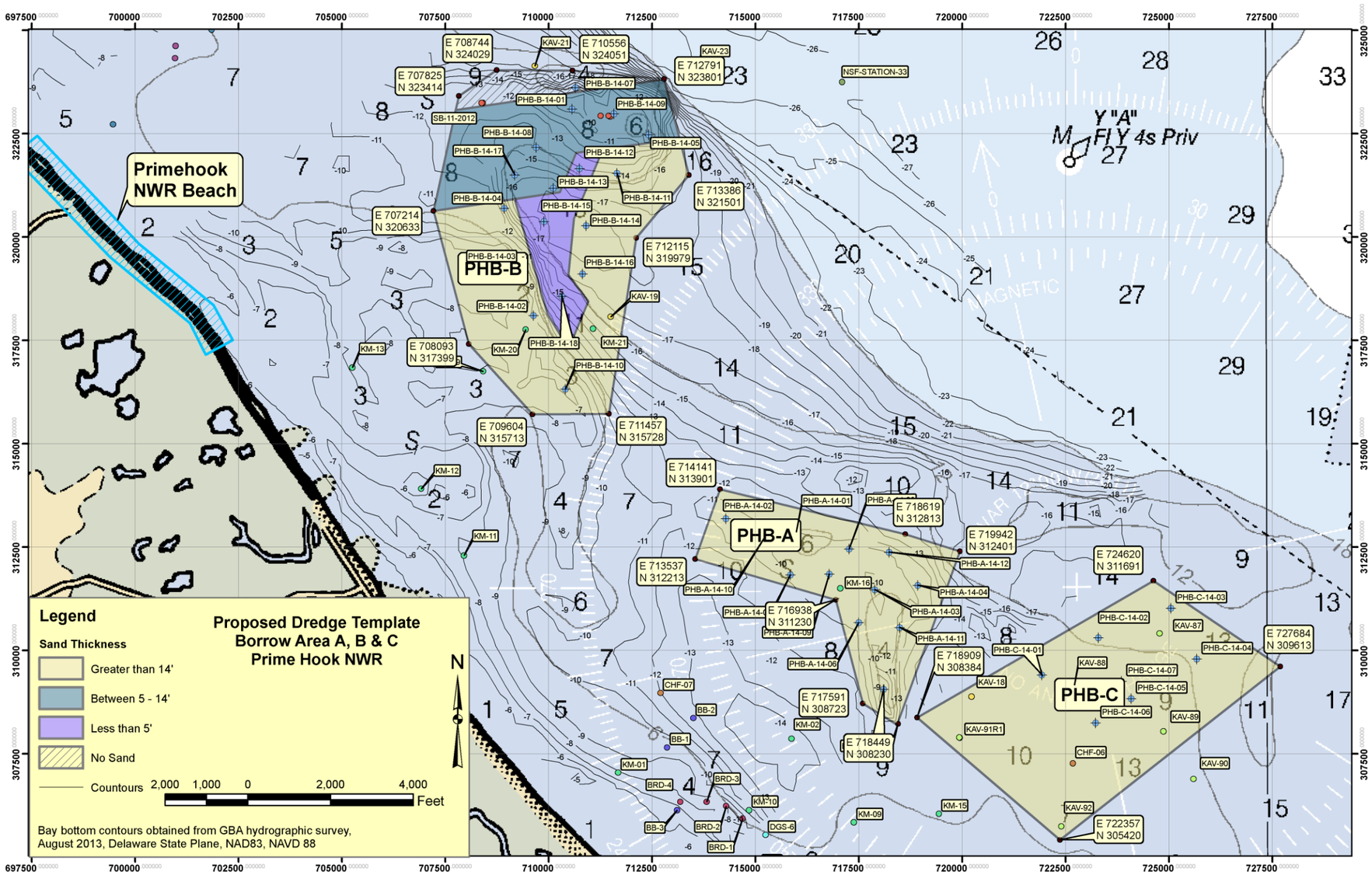


Figure 3-8: Vibracore locations and sand depths for PHB-B, PHB-A, and PHB-C.

3.6.2 Planktonic and Benthic Organisms

Phytoplankton are the dominant source of organic matter at the base of the marine food web in the lower Delaware Bay. Dominant species vary with seasons. Small flagellates are common in summer and early fall while diatoms dominate from fall to spring (Watling and Maurer, 1976). The primary consumers of phytoplankton are zooplankton. Copepods are the predominant zooplankton species within the lower bay, along with mysid crustaceans, a significant food source for juvenile fish. The flora was composed primarily of small flagellates during the summer and early fall, while diatoms dominated from October to May. Peak cell numbers occurred during fall and early spring blooms. Evenness diversity was lowest during periods of maximum diatom abundance and highest when microflagellates predominated. There was a gradual shift in dominance, except during the early spring *Skeletonema costatum* bloom.

Copepods provide a major food for developing fishes. Common species include *Halicyclops fosteri*, *Eurytemora affinis*, and *Acaryia tonsa*. Mysid shrimp (*Neomysis americana*) also provide a significant food source for fish. Ecologically important crustaceans include the grass shrimp (*Palaemonetes* spp.), fiddler crab (*Uca* spp.), and blue crab (*Calinectes sapidus*). The wedge rangia (*Rangia cuneata*) is an important bivalve filter feeder in soft bottom habitats, and the coffee-bean snail (*Melampus bidentatus*) serves as a detrial/algal razer in marshes (USACE, 2014).

The Eastern oyster (*Crassostrea virginica*) is a keystone species of the Delaware Bay from the mouth up to the Bombay Hook NWR near Leipsic, Delaware. Delaware oyster seed beds cover about 1,331acres (Wilson *et al*., unpub.) but are not in the vicinity of the proposed project. The southernmost of these beds occur primarily in the mid-bay region 18 to 27 miles north of the refuge.

The sandbuilder worm (*Sabellaria vulgaris*) occurs along temperate shorelines, including in the Mid-Atlantic, but only in dense, reef-like structures in the lower portion of the Delaware Estuary (Brown and Miller, 2011). Similar to oysters, sabellariid tube-building worms create structural habitat for a variety of benthic invertebrates, higher diversity than surrounding sediments, and provides an additional stabilizing force along beaches (Wells, 1970; Gore *et al*., 1978; Dubois *et al*., 2002). Intertidal aggregations have been found between Slaughter Beach and Cape Henlopen, extending parallel to the shoreline (Amos, 1966; Wells, 1970; Curtis, 1973,1975).

More research is needed to document *Sabellaria* reef in lower Delaware Bay to understand what factors control spatial and temporal changes in their distribution. Conclusions drawn to date include a requirement for wave-induced sediment resuspenion due to wind fetch, proximity to the mouth of the bay, salinity, and nearshore bathymetry (Polis and Kupferman, 1973; Maurmeyer, 1978; Jackson and Nordstrom, 1993; Saini *et al*., 2009). Brown and Miller (2011) studied distribution and persistence of sabellariid reefs and aggregations from 2001 to 2009 and found them present only on certain beaches in Delaware Bay. Reefs occurred at south Slaughter Beach, Fowler Beach, Prime Hook Beach, and north Broadkill Beach, while aggregations were found at Port Mahon, Pickering Beach, Kitts Hummock, Bowers Beach, South Bowers Beach, and north Slaughter Beach. The linear extent of sabellariids at all of these beaches was subject to both natural and anthropogenic disturbances. Slaughter Beach had the greatest extent during the study period but densities varied considerably from year to year. At Slaughter Beach, *Sabellaria* structures decreased from 99 percent in 2004 to 41 percent in 2007, but increased to 89 percent in 2008. Large platform reefs at Fowler Beach decreased from 19 percent in 2006 to 7 percent in 2007 and completely disappeared by autumn 2008. Prime Hook Beach had short ribbon reefs and isolated aggregations that decreased from 29 percent in 2007 to 11 percent in 2008. Certain portions of south Broadkill Beach (south of the old inlet jetty) and large stretches of Prime Hook Beach and Fowler

Beach had neither aggregations or reefs, and therefore concluded by the researchers to be unsuitable for *Sabellaria* growth.

The sub-tidal distribution of *Sabellaria* in the lower Delaware Bay is closely tied to the bottom sediment available for the worms to construct their tubes (mainly fine to medium grains), but also the availability of hard stable material to grow their tubes upon (*e.g*. gravel, cobbles, and/or shells). The major limiting factor in the lack of widespread colonization of *Sabellaria* is the lack of hard substrate material. *S. vulgaris* tubes do occur in areas without stable substrate, but infrequently, and are easily destroyed by natural (*e.g.* storms, tidal currents, shifting sediments, horseshoe crab migration) and anthropomorphic processes (*e.g*. anchor dragging, shellfish dredging, and boat prop scarring).

Bottom sediment and benthic habitat mapping conducted in 2005 by DNREC identified regions offshore of Fowlers Beach and Broadkill Beach with fine to medium sand with gravel (Figure 3-9: darker orange to brown colored areas). Borrow Area PHB-B contains a fine to medium sand surface cover, however, it does not have the coarser gravel component for tube adhesion. Therefore, the likelihood of this area providing potential habitat for *Sabellaria* is considered low.

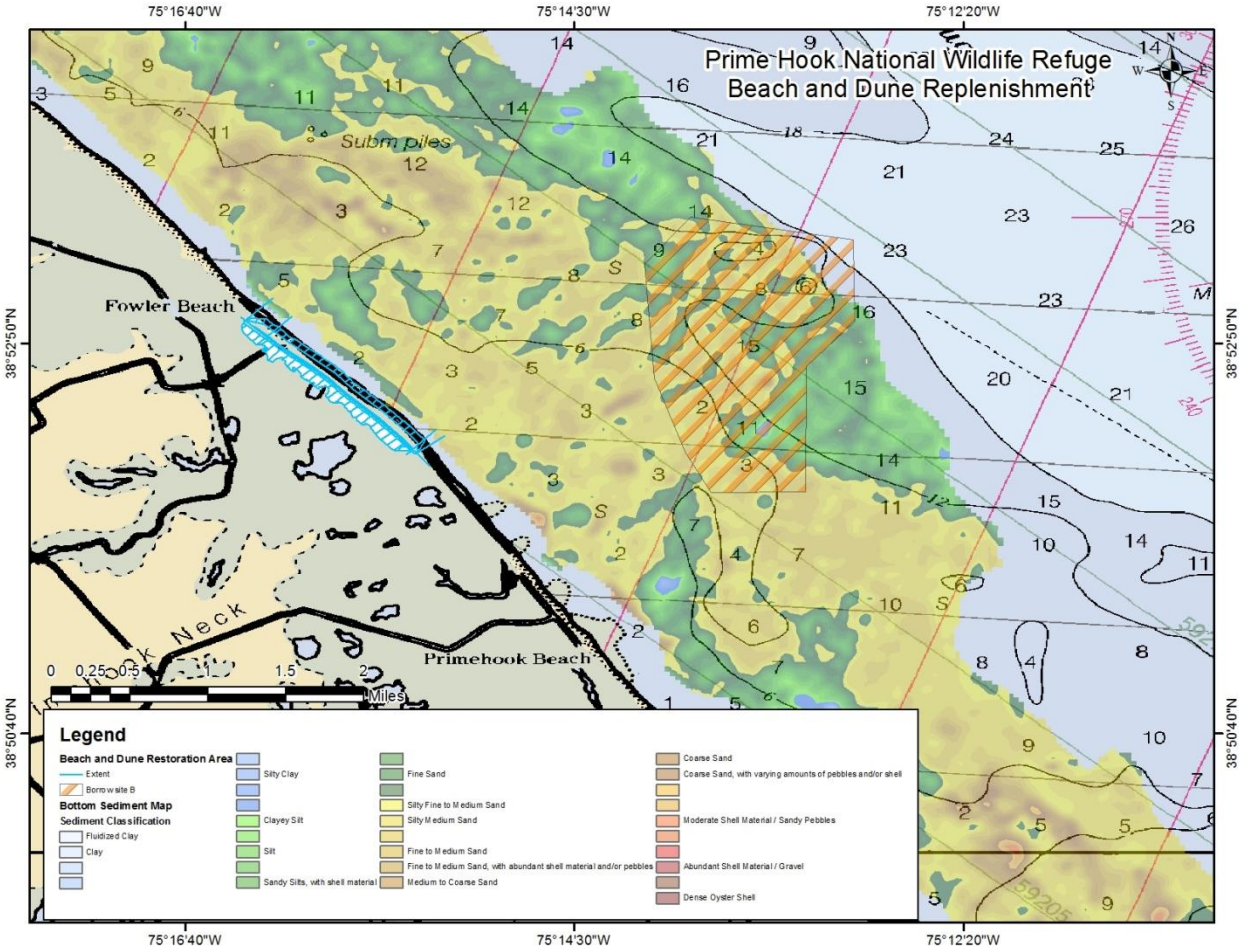


Figure 3-9: Bottom surface sediment distribution for the Fowler Beach, Prime Hook Beach, and Borrow Area PHB-B regions.

The blue crab (*Callinectes sapidus*) inhabit nearshore coastal and estuarine habitats. Delaware Bay is the northernmost range of blue crab distribution (Helser and Kahn, 2001). Females reach reproductive maturity in their first year after their first molt, overwinter, and produce eggs in the following summer. Females can spawn twice in their first year (Churchill, 1919; Van Engel, 1958), however, it is believed that not all females survive winter and spawn the following summer. Winter appears to be a time of highest mortality for mature crabs in Delaware Bay, according to anecdotal reports from watermen. Larvae hatch in the summer, peaking in numbers in July. They exit the Bay and the current hypothesis is that they travel southward in a current until southwesterly winds push them further offshore and back north toward the mouth of the Bay (Epifanio, 1995). Major re-entry into the Bay as megalopae is hypothesized to occur during northeasters in the late summer and autumn.

Marshes are important habitats for many fish and invertebrate species, including the blue crab. Jivoff and Able (2003) investigated the response of blue crabs in recently restored marshes that were once salt hay farms as compared to blue crabs in nearby reference marshes with similar physical characteristics. They found that blue crabs were more abundant in restored marshes, but molting frequency and population sex ratios were indistinguishable in restored marshes and reference marshes, suggesting that restored marshes attract crabs and support their growth.

The Delaware Bay serves as a major horseshoe crab (*Limulus polyphemus*) spawning ground. Adults gather on bay beaches during the high tides of the full and new moons in May and June. Factors influencing spawning include lunar cycle, wave height, beach slope, and substrate. Beach morphology (*i.e.* sediment type and grain size) affects oxygen, temperature, and moisture gradients, which in turn, affect egg survivability. Horseshoe crabs can detect hydrogen sulfide, which is produced in peat substrates typically found along severely eroded bay shoreline (Botton *et al*., 1988; Thompson, 1999). Peat shorelines also render the crabs more susceptible to stranding with its irregular topography. Botton and Loveland (1989) estimated that at least 190,000 horseshoe crabs died from beach strandings along the New Jersey shore of the Delaware Bay during the 1986 spawning season (May to June). Horseshoe crabs favor sandy beaches with a gentle slope (Botton and Loveland, 1987). In addition to the intertidal zone used for spawning, horseshoe crabs use the adjacent shallow waters and tidal flats as nursery habitat for juvenile life stages. The presence of these offshore features may influence where horseshoe crabs congregate to wait for full moon high tides as these flats provide protection from wave energy (Thompson, 1998). Sand flats also provide food sources for juvenile horseshoe crabs. Horseshoe crab eggs provide a critical food resource to migrating shorebirds (see Section 3.7 and 3.8). The horseshoe crab is economically valued for as bait for the American eel and conch fisheries, and in the manufacture of medical testing products, although limits on harvesting have been implemented.

3.6.3 Fish

The Delaware estuary also supports over 200 fish species, both residents and migrants. River herring (*Alosa* spp.) are anadromous species that live in the ocean but migrate upbay to spawn in freshwater reaches of the river. Some commercially and recreationally important fisheries include striped bass (*Morone saxatilis*), weakfish (*Cynoscion regalis*), summer flounder (*Paralichthys dentatus*), croaker (*Micropogonias undulates*), and menhaden (*Brevoortia tyrannis*)(McHugh, 1981). Wetlands are important nursery areas for juvenile fish. There are at least 31 species that are commercially harvested from the Delaware Estuary. Other notable fish inhabitants include several species of sharks skates, and rays including sand tiger (*Carcharias Taurus*) and sandbar (*Carcharhinus* plumbeus) sharks, the cow-nosed stingray (*Rhinoptera* bonasus), and clear-nose skate (*Raja eglanteria*). For a more detailed historical discussion on estuarine species, refer to chapter 3 of the CCP/EIS (2012). Recent fish

community surveys have been completed within the refuge impoundments, using clover traps, beach seines, and/or fyke nets. Species encountered are provided in Table 3-3.

Table 3-3: Summary of fish species captured in 2014 during summer and fall surveys throughout the project area.

Species	**Unit II Impoundment**		**Unit III Impoundment**		**Upper Prime Hook Creek**	
	Summer	***Fall***	***Summer***	***Fall***	***Summer***	***Fall***
American Eel (*Anguilla rostrate*)			X	X	X	X
Atlantic Croaker (*Micropogonias undulates*)	X					
Atlantic Silverside (*Menidia menidia*)	X	X	X	X		
Banded Killifish (*Fundulus diaphanous*)	X	X				
Bay Anchovy (*Anchoa mitchilli*)	X	X				
Black Crappie (*Pomoxis nigromaculatus*)					X	
Black Drum (*Pogonias cromis*)	X			X		
Bluegill (*Lepomis macrochirus*)					X	
Brown Bullhead (*Ameiurus nebulosus*)					X	
Common Carp (*Cyprinus carpio*)					X	X
Gizzard Shad (*Dorosoma cepedianum*)		X			X	X
Goldfish (*Carassius auratus*)					X	
Inland Silverside (*Menidia beryllina*)	X		X	X		X
Menhaden (*Brevoortia tyrannus*)	X					
Mummichog (*Fundulus heteroclitus*)	X	X	X	X		X
Naked Goby (*Gobiosoma bosci*)		X		X		
Norfolk Spot (*Leiostomus xanthurus*)	X					
Northern Pipefish (*Syngnathus fuscus*)	X					
Rainwater Killifish (*Lucania parva*)				X		
Redbreast Sunfish (*Lepomis auritus*)					X	
Sheepshead Minnow (*Cyprinodon variegatus*)	X	X	X	X		X
Striped Anchovy (*Anchoa hepsetus*)	X					
Striped Bass (*Morone saxatilis*)		X				
Striped Killifish (*Fundulus majalis*)	X	X		X		
Weakfish (*Cynoscion regalis*)	X					
White Catfish (*Ameiurus catus*)			X			
White Perch (*Morone americana*)	X		X	X	X	X

3.6.4 Essential Fish Habitat Assessment

Under provisions of the reauthorized Magnuson-Stevens Fishery Conservation and Management Act of 1996, the project area including the borrow area, nearshore and intertidal areas, were designated as Essential Fish Habitat (EFH) for species with Fishery Management Plans (FMP's), and their important prey species. The project site is located within the 10 feet by 10 feet square for waters within the salt water salinity zone of Delaware Bay affecting the following: from Big Stone Beach on the north, south to Prime Hook Beach, Prime Hook Creek, and Prime Hook Neck, including waters affecting within the Mispillion River, Cedar Beach, Cedar Creek, Slaughter Beach, Slaughter Neck, Slaughter Creek, and

Fowler Beach, all east and southeast of Milford Neck and Milford, Delaware (Guide to Essential Fish Habitat Designations in the Northeastern U.S., Volume IV: New Jersey and Delaware, March 1999). The study area contains EFH for various life stages for 19 species of managed fish and shellfish. Table 3-3 presents the managed species and their life stage that EFH is identified for within the 10 by 10 minute square (#9307510) that covers the affected area.

Table 3-4: Summary of Essential Fish Habitat designated species and their life stages within the Delaware Estuary Mixing Zone (Square 9307510).

Managed Species	Eggs	Larvae	Juveniles	Adults	Spawning Adults
Redfish (Sebastus fasciatus)	**n/a**				
Red Hake (Urophycis chuss)				**X**	
Winter flounder (Pleuronectes americanus)	**X**	**X**	**X**	**X**	**X**
Windowpane flounder (Scopthalmus aquosus)	**X**	**X**	**X**	**X**	**X**
Atlantic sea herring *(Clupea harengus)*			**X**	**X**	
American plaice (Hippoglossoides platessoides)			**X**		
Bluefish (Pomatomus saltatrix)			**X**	**X**	
Long finned squid *(Loligo pealei)*	**n/a**	**n/a**			
Short finned squid *(Illex ilecebrosus)*	**n/a**	**n/a**			
Atlantic butterfish *(Peprilus tricanthus)*		**X**	**X**	**X**	
Summer flounder (Paralicthys dentatus)			**X**	**X**	
Scup (Stenotomus chrysops)			**X**	**X**	
Black sea bass (Centropristus striata)			**X**	**X**	
Surfclam (Spisula solidissima)	**n/a**	**n/a**			

Managed Species	Eggs	Larvae	Juveniles	Adults	Spawning Adults
Ocean quahog (Artica islandica)	**n/a**	**n/a**			
Spiny dogfish (Squalus acanthias)	**n/a**	**n/a**			
King mackerel (Scomberomorus cavalla)	**X**	**X**	**X**	**X**	
Spanish mackerel (Scomberomorus maculatus)	**X**	**X**	**X**	**X**	
Cobia (Rachycentron canadum)	**X**	**X**	**X**	**X**	
Clearnose skate (*Raja eglantteria*)			**X**	**X**	
Little skate (Leucoraja erinacea)			**X**	**X**	
Winter skate (Leucoraja ocellata)			**X**	**X**	
Sand tiger shark (Carcharias taurus)		**X neonates***		**X**	
Dusky shark (Carcharhinus obscurus)		**X neonates***			
Sandbar shark (Carcharhinus plumbeus)		**X neonates* (HAPC)**	**X (HAPC)**	**X (HAPC)**	

"n/a": species either have no data available on designated lifestages, or those lifestages are not present in the species reproductive cycle.

***neonates: sharks do not have a larval stage.**

3.7 Wildlife

The lower Delaware Estuary is recognized internationally as an important ecosystem for millions of resting and foraging migratory shorebirds each spring and fall. Species such as ruddy turnstones (*Arenaria interpres*), short-billed dowitchers (*Limnodromus griseus*), semi-palmated sandpipers (*Calidris pusilla*), sanderlings (*Calidris alba*), and the imperiled red knot (*Calidrus canutus*) fly from southern Argentina each spring and stop at the Delaware Bay to rest and feed on amphipods, chironomids, and horseshoe crab eggs (Chipley, 2003). The total number of shorebirds counted in aerial surveys in Delaware Bay over a 6-week migration period from May to mid-June range from 250,000 to more than 1,000,000 birds. Birds observed in tidal marsh habitats are estimated at 700,000.

Bird species known to occur within the refuge's wetlands include raptors, waders, passerines, and waterfowl. Some areas within the interior of the refuge are naturally freshwater and provide habitat conditions for migrating and wintering birds, and abundant food resources for mallard (*Anas platyrhynchos*), American black duck (*Anas rubripes*), northern pintail (*Anas acuta*), and wood duck (*Aix sponsa*). Canada geese (*Branta canadensis*) and snow geese (*Chen caerulescens*) frequent the region during fall, winter, and spring. Existing saltmarshes on the refuge support secretive marshbirds such as clapper rail (*Rallus longirostris*), and saltmarsh obligate nesting species such as seaside sparrow (*Ammodramus maritimus*), salmarsh sparrow (*Ammodramus caudacutus*), and willet (*Tringa semipalmata*). Typical faunal species that may be found at the project site or within the interior of the refuge are presented in Table 3-5.

Table 3-5: Faunal species that may be found at the Prime Hook National Wildlife Refuge project site.

Amphibians			
American toad	**Bufo americanus**	**leopard frog**	**Rana pipens**
Reptiles			
Common snapping turtle	**Chelydra serpentine**	**eastern garter snake**	**Thamnophi sirtalis**
Smooth green snake	**Opheodrys vernalis**	**Kemp's Ridley turtle**	**Lepidochelys kempii**
Hawksbill turtle	**Eretmochelys imbricata**	**loggerhead turtle**	**Caretta caretta**
Diamondback terrapin	**Malaclemys terrapin terrapin**	**green turtle**	**Chelonia mydas**
Birds			
Peregine falcon	**Falco perginus**	**osprey**	**Pandion halieatus**
bald eagle	**Haliaeetus leucocephalus**	**northern harrier**	**Circus cyaneus**
American bittern	**Botaurus lentiginosus**	**least bittern**	**Ixobrychus exilis**
great blue heron	**Ardea herodias**	**little blue heron**	**Egretta caerulea**
tri-colored heron	**Egretta tricolor**	**green-back heron**	**Butorides stratus**
black-crowned night heron	**Nycticorax nyticorax**	**snowy egret**	**Egretta thula**
Yellow-crowned night heron	**Nycticorax violaceus**	**great egret**	**Casmerodius albus**
Glossy egret	**Plegadis falcinellus**	**black duck**	**Anas rubripes**
Mallard	**Anas platyrhynchos**	**green-winged teal**	**Anas crecca**
king rail	**Rallus elegans**	**black rail**	**Laterallus jamaicensis**
Northern clapper rail	**Rallus longerostris crepitans**	**marsh wren**	**Cistothorus palustris**
Coastal plain swamp sparrow	**Melospiza georgiana**	**Least tern**	**Sternula antillarum**
Mammals			
Raccoon	**Procyon lotor**	**eastern grey squirrel**	**Sciurus carolinensis**
Striped skunk	**Mephitis mephitis**	**woodchuck**	**Marmotoa monax**
white-footed mouse	**Peromyscus leucopus**	**house mouse**	**Mus musculus**
Norway rat	**Rattus norvegicus**	**eastern cottontail**	**Sylvilagus floridanus**
marsh rice rat	**Oryzomys palustris**	**muskrat**	**Ondatra zibethicus**

3.8 Threatened and Endangered Species

A resident formally federally endangered species within the refuge is the Delmarva fox squirrel (*Sciurus niger cinereus*), although at the time of this report preparation, the Service was finalizing a proposed rule to delist the species. In more recent years, the federally and State-listed endangered piping plover have been sited using adjacent sandy beach areas for foraging but have not been observed nesting on the refuge to date. The Service proposed in 2006 to list the *rufa* subspecies of the red knot (*Calidris canutus rufa*) due to the high magnitude of imminent threats to the subspecies and it remained a candidate species. In January of 2015 the service formally, listed the red knot as a threatened species throughout its range, including Delaware. Red knots fly 19,000 miles round-trip between wintering and breeding grounds. After leaving its wintering grounds in southern Argentina, the red knot makes only one stop on the coast of Brazil, and then flies nonstop to Delaware Bay, which is a distance of 5,000 miles (Chipley, 2003).

In October 2013, the Service also proposed a combined rule to list the northern long-eared bat and the eastern small-footed bat. The Service found that listing the northern long-eared bat as endangered was warranted but not warranted for the small-footed bat. These species have not been confirmed as refuge residents, however, it is possible that the northern long-eared bat may occur in the area based on their presence in surrounding states and suitable habitat, while the eastern small footed bat is less likely to occur in the area, considering its only known winter habitat are caves and mines (Delaware Division of Fish and Wildlife).

In 2010, the NMFS proposed to list three Distinct Population Segments (DPSs) of the Atlantic sturgeon (*Acipenser oxyrhinchus oxyrinchus*) in the Northeast Region. The New York Bight DPS, which includes Atlantic sturgeon whose range extends into coastal waters of Long Island, the New York Bight, and the Delaware Bay, from Chatham, Massachusetts to the Delaware-Maryland border of Fenwick Island, as well as wherever these fish occur in coastal bays, estuaries, and the marine environment from the Bay of Fundy, Canada to the Saint Johns River, Florida. In 2012, NMFS issued rulings listing five DPSs of Atlantic sturgeon as threatened or endangered under the ESA. All five of these DPSs may occur within waters of the Delaware Bay. Atlantic sturgeon are anadromous, spending a majority of their adult life phase in marine waters, migrating upriver to spawn in freshwater reaches of the Delaware River, then migrating to lower estuarine brackish areas during juvenile growth phases. Adults migrate along the ocean coast of New Jersey and Delaware.

Atlantic sturgeon capture records between 1958 to 1980 (Brundage and Meadows, 1982) indicated that the fish are most abundant in Delaware Bay in early spring, and move up to the lower tidal river during summer, utilizing different regions of the river and bay depending on season and life history stage. Juvenile Atlantic sturgeon are believed to overwinter in deeper waters of the lower estuary, as numbers increased in September. Commercial trawl fishermen in 1978 to1979 indicated that Atlantic sturgeon are commonly taken near the mouth of the Delaware Bay in fall. However, a compilation of incidental catch records and anecdotal information does not take into consideration catch per unit effort (Brundage and Meadows, 1982).

An acoustic telemetry and netting survey conducted in the lower tidal Delaware River from May 2005 through December 2006 (Brundage and O'Herron, 2009) acoustically tagged one juvenile Atlantic sturgeon that exhibited directed movement from the lower tidal river to Delaware Bay in fall and showed a preference for deeper waters. Simpson's (2008) telemetry study of 32 Atlantic sturgeon showed the fish entering the Delaware Estuary in early spring (mid-March through mid-May) and moving upriver, concentrating in deeper waters. This apparent affinity of juvenile Atlantic sturgeon for deeper water within the Delaware River is consistent with earlier studies (Lazzari *et al*., 1986; Shirey, 1997) and for other rivers (Haley *et al*., 1996; Bain, 1997; Sweka *et al*., 2007). Some juveniles may remain in the tidal freshwater reaches of the river to overwinter, as evidenced by the capture of an early juvenile in the lower

tidal river in February by Burton *et al*. (2005) and the capture of several juveniles in the upper tidal river during December through February by Lazzari *et al*. (1986) and O'Herron (unpublished data). Studies in the Delaware Estuary of the 2009 year class showed 27 percent (3 of 11 fish tagged in the fall of 2010) went to the ocean in December 2010. Results of more recent acoustic tagging studies in the western lower Delaware Bay revealed that adult and sub-adult Atlantic sturgeon leave the bay in the winter (departing in October to early November) and return in the spring (late March to late May) (D. Fox, unpublished data).

In addition to the Atlantic and shortnose sturgeons, the NMFS has jurisdiction over other listed species that may occur in the project vicinity. These include the endangered Kemp's Ridley turtle (*Lepidochelys kempii*), leatherback (*Dermochelys coriacea*), loggerhead turtle, (*Caretta caretta*), and green turtle (*Chelonia mydas*) (J. Goebel, NMFS, pers. comm). Some marine mammals may be classified as threatened or endangered species, but all fall under the jurisdiction of the Marine Mammal Protection Act. The marine mammal species that are commonly encountered in the Delaware Estuary are bottlenose dolphin (*Tursiops truncatus*), harbor porpoise (*Phocoena phocoena*), humpback whale (*Megatera novaeangliae*), harbor seal (*Phoca vitulina concolor*), and gray seal (*Halichooerus grypus*). Species not commonly sighted but which may incidentally utilize the estuary are pygmy sperm whale (*Kogia breviceps*), long-finned pilot whale (*Globicephala melaena*), fin whale (*Balaenoptera physalus*), northern right whale (*Eubalaena glacialis*), harp seal (*Cystophora cristata*), and ringed seal (*Poca hispida*).

The shortnose sturgeon (*A. bevirostrum*) is also a federally listed endangered species, and occurs primarily in the upriver portion of the Delaware Estuary and is not expected to occur in the project area. Although shortnose sturgeon do not undertake the significant marine migrations seen in Atlantic sturgeon, telemetry data indicates that shortnose sturgeon do make localized coastal migrations but more likely in other areas such as the Gulf of Maine and among rivers in the Southeast. Interbasin movements have been documented for shortnose sturgeon between the Delaware River and Chesapeake Bay via the Chesapeake and Delaware (C&D) Canal (NMFS, 2011).

Although the bald eagle (*Haliaeetus leucocephalus*) and the peregrine falcon (*Falco* peregrines) have been recently removed from the Federal endangered species list, these raptors do occur in the project area. The bald eagle is still protected under the Bald and Golden Eagle Protection Act and both birds are protected under the Migratory Bird Treaty Act.

The State-endangered resident species on the refuge include the bald eagle, pied-billed grebe (*Podilymbus podiceps*), northern harrier (*Circus cyaneus*), Cooper's hawk (*Accipiter cooperii*), black rail (*Laterallus jamaicensis*), and Forster's tern (*Sterna forsteri*). State-endangered species that have attempted to breed on the refuge include the American oystercatcher (*Haematopus palliates*), least tern (*Sternula antillarum*), and common tern (*Sterna hirundo*). Rare sightings of other State-endangered species using the refuge in the spring, fall, or winter include the brown creeper (*Certhia Americana*), black-crowned night heron (*Nycticorax nycticorax*), yellow-crowned night heron (*Nyctanassa violacea*), hooded warbler (*Setophaga citrine*), red-headed woodpecker (*Melanerpes erythrocephalus*), and sedge wren (*Cistothorus platensis*).

The Delaware Natural Heritage Program (DNHP) collected baseline data on rare, endangered and threatened flora and fauna. During the 2004/2005 plant surveys, rare plants and invertebrates, herpetafauna, odonates, lepidopterans, and small mammals were identified on the refuge (McAvoy *et al*., 2007). Exemplary natural communities are those that contain high diversity of rare plant species and have minimal anthropogenic impact. The most significant community found at the refuge is the twig rush peat mat, which supports many State rare plant species. One area referred to as the Prime Hook Bog is 1.5 acres in size and contains 66 plant species and varieties. Twig rush sedge (*Cladium mariscoides*) is the dominant herb, and had 24 associated rare plant species, including several insectivorous plants such as the purple pitcherplant (*Sarracenia purpurea)*), round-leaf sundew (*Drosera rotundifolia*), fibrous

bladderwort (*Utricularia fibrosa*), and southern bladderwort (*Utricularia juncea*). In addition, a subspecies new to the flora of the State of Delaware and the Delmarva Peninsula was found on the refuge: bushy bluestem (*Andropogon glomeratus* var. *hirsutior*).

Rare flora within the forest community type red-maple/seaside alder woodland occurs only at the refuge and may not occur anywhere else in Delaware or North America. The community is dominated by red maple (*Acer rubrum*) and seaside alder (*Alnus* maritime) in the overstory and a swamp environment of standing water with a shrub layer of species such as water willow (*Decadon verticillatus*), sweet pepperbush (*Clethra alnifolia*), and southern bayberry (*Morella caroliniensis*). Management Unit III possesses the largest known population in the State of lance-leaf orange milkweed (*Asclepias lanceolata*). A Coastal Bayshore/Succulent Bush community is found in Management Unit IV and dominated by sea purslane (*Sesuvium portulacastrum*) and panic beachgrass (*Panicum amarum*). This community is not known to occur anywhere else in Delaware. For a more detailed listing of rare plants found within the refuge, refer to chapter 3 of the CCP/EIS (2012).

3.9 Climate and the Influence of Sea Level Rise on the Physical Environment

The Delmarva Peninsula climate is generally mild with continental weather moderated by the effects of the Delaware Bay and Atlantic Ocean, causing only brief periods of sustained extreme cold or hot temperatures. Within Prime Hook NWR, temperatures range between 32 to 80 degrees F. Typically, summer ocean and bay breezes keep the refuge cooler than inland areas. Annual and seasonal precipitation is highly variable. Average annual rainfall is 41.98 inches and snowfall is generally light, averaging 10 to 15 inches per year. Average annual wind speed is about 9 miles per hour, but winds can reach 40 to 50 miles per hour during intense storms, particularly in winter or early spring.

Hurricanes are more powerful than coastal storms, but coastal storms are more frequent in Delaware. While hurricane season generally runs from June through November, coastal storms, commonly referred to as nor'easters, are a year-round threat to coastal areas. Storm surge, in combination with strong and constant winds and torrential rainfall, sometimes lasting for several days, can cause extensive flooding and increase coastal erosion. For a description of historical storms that have impacted coastal Delaware, refer to the chapter 3 of the CCP/EIS, 2012).

Sandy shorelines shift landward and seaward constantly as a result of sediment supply, land subsidence, weather conditions, human activities, tides, and storms and erosion. Global sea level is estimated by averaging measurements taken from a worldwide network of coastal tide gauges or from satellite instruments. However, sea level changes vary geographically and should be addressed locally as a management issue. The long-term tide gauge data records a 20th century average global SLR of about +1 to 2 mm/year. Many studies addressing global SLR over the past 150 years establish an average rate of 1.7 to 1.8 mm/year (Najjar *et al.*, 2010; Church and White, 2006). The Intergovernmental Panel on Climate Change (IPCC), based on the same records, estimated an average rate of global rise between 1900 and 2000 of 1.6 mm/year (2007; 4th Assessment Report) and between 1901 and 2010: 1.7 +- 0.2 mm/year (2013; 5th Assessment Report). However, these global averages do not include both short-term and multi-decadal changes in sea level resulting from meteorological and oceanographic oscillations or the local and regional influences of land movement (deLange and Carter, 2014). The dominance of local and regional factors influencing SLR will be discussed specific to conditions within the refuge in Section 4.

3.10 Cultural Resources

All activities for this undertaking are located in the Area of Potential Effect (APE) which includes the offshore borrow areas and refuge Units I, II and III. The proposed Federal undertaking for the Prime Hook NWR consists of four main activities that may have the potential to cause effects on historic properties pursuant to 36 CFR 800.3: (1) potential nearshore sand borrow areas; (2) 6,400 linear feet of dune and beach berm construction; (3) wetland restoration via dredging and thin layer sidecast of sediment within approximately 30 miles of existing channel conveyances; and, (4) three potential staging and access areas. Other actions related to the overall completion of hydrologic connectivity, but not a part of this undertaking, include: (1) the removal of an 1,800-foot section of Fowler's Beach Road; and, (2) the removal of a section of Prime Hook Beach Road to be replaced by a 60-foot long bridge. The Section 106 process for the Fowler Beach Road removal will be completed by the Service. The Section 106 process for the new bridge on Prime Hook Beach Road will be completed by Delaware Department of Transportation (DelDOT).

3.10.1 Marine Existing Conditions

Prehistoric Maritime Overview
Although only a few inundated prehistoric terrestrial cultural resource sites have been identified along the Mid-Atlantic Continental Shelf, the potential for inundated sites has been recognized. Patterns of prehistoric human activity on the Atlantic Continental Shelf were tied to dramatically changing environmental conditions. At the onset of the Wisconsin Stage of the Pleistocene Epoch a general cooling of the earth occurred. The dramatic expansion of vast polar ice caps created a significant reduction in sea level. Landforms exposed by receding water reshaped the continent. A terrestrial ecology associated with cold-adapted boreal forests and or tundra and upland geomorphology developed (Vokes, 1957).

A warming trend, initiated at the end of the Wisconsin Stage of the Pleistocene Epoch, approximately 15,000 Before Present (B.P.), began to reverse the process of severe weather patterns. Melting glacial ice and post-glacial rebounding of the tectonic plates produced an erratic but rising sea level. Since the inception of the Pleistocene, the Atlantic Continental Shelf has been inundated several times. While short term rates of post-Pleistocene SLR vary, most researchers support the concept of a rapid rise in sea level prior to 5,000 years ago. Since that time, local rise in sea level is generally estimated to be approximately 6 inches per century. As a result of this SLR, the Atlantic Coast has been migrating to the west. It is not uncommon to see evidence of a migration of several hundred feet in some localized areas during recorded history (Vokes, 1957). During periods of lower sea level the prehistoric populations of the Delmarva Peninsula are assumed to have exploited the exposed Continental Shelf.

Examination of the study area geomorphology and environment provides some insight into the nature and condition of submerged cultural resources that might exist along the Delaware Coast. It is possible that the inundation of prehistoric archaeological sites would have resulted in extensive resorting of the archaeological record. While artifacts preserved in the bottom sediments could exist in an excellent state of preservation, the associated context of human activity may have been destroyed. The high-energy environment that is present along the coastline would lessen the likelihood that fragile evidence of prehistoric populations would survive. However, there are examples where terrestrial archaeological sites have survived the inundation process. Evidence from inundated Karst formation sites in Sarasota County, Florida (Clausen, 1975) and in the Gulf of Mexico off Fort Myers (Ruppe, 1979) indicate that the archaeological record associated with prehistoric sites is not always destroyed. However, much depends on the local conditions and insufficient evidence has been generated to support broad generalizations.

Perhaps the most comprehensive treatment of the subject is "A Summary and Analysis of Cultural Resource Information on the Continental Shelf from the Bay of Fundy to Cape Hatteras" (Bourque *et al*., 1979). Volume II of the study treats archaeology and paleontology. Although the potential for earlier sites was assessed as low, the potential for Archaic sites (dating to the period between 5,000 and 8,500 years ago) was defined as medium to high. Although the location and identification of submerged Archaic sites would be difficult, their association with detectable shell middens should enhance the possibilities. Investigations in the Gulf of Mexico off the west coast of Florida (Ruppe, 1979) have confirmed both the association of prehistoric material with submerged middens and their detectability using side scan sonar remote sensing.

Historic Maritime Overview

The effect of geomorphology and environment on shipwreck material can be quite different. In most cases the remains of shipwrecks are not subjected to the processes of inundation. Shipwreck material deposited in even the shallowest environment can settle rapidly into the bottom with its associated archaeological record intact. The wreck of the DeBraak (1798), discovered at the mouth of Delaware Bay provides a classic example. A good portion of the lower hull survived intact, along with an extensive associated artifact assemblage. A second local example of site integrity comes from the Roosevelt Inlet wreck (ca. 1783). Located in 2005 at the mouth of Delaware Bay near Roosevelt Inlet, this site had had very little surviving hull structure but contained a large volume of well-preserved cultural material from the vessel's cargo. These two examples at the mouth of Delaware Bay confirm that even in extremely high-energy environments, archaeological evidence of historic wreck sites almost inevitably survives. Numerous other archaeological investigations off the coasts of the states of Maine, Massachusetts, New Jersey, Virginia, Maryland, New York, North Carolina, Florida, and Texas, and the countries of England, Greece, Italy, Israel, and Turkey, offer examples that ship remains survived to preserve valuable archaeological data.

At many of the shipwreck sites sand and light mud similar to the bottom sediments in portions of the study area provided an excellent environment for preservation. Given the level of maritime activity in Delaware Bay, the extent of vessel losses in the vicinity of the study areas, and the level of preservation at shipwreck sites in other similar environments, it is probable that well-preserved shipwreck sites exist in the vicinity of the study areas.

Potential submerged cultural resource types in the project vicinities may include a variety of material dating from the first half of the 17th century through the Second World War. Several recent shipping disasters that occurred within the last 60 years are also listed. To discuss the types of vessels potentially present, it is necessary to include vessels from all phases of the commercial and naval activity in and out of Delaware Bay and along the Delaware portion of the Atlantic coast. Wood-hulled ships, ranging from small fishing sloops, shallops, recreational sailing and motor craft, and coastal schooners, to ship-rigged warships, have been lost near the mouth of Delaware Bay. Iron-hulled vessels, including paddle wheel steamboats and World War II-era merchant ships sunk by German submarines, have also been lost in the project vicinity. Large 20th century steamships and freighters are among the listed losses in the region. Many of these types of vessels would potentially lend historic insights into a wide range of maritime related topics, including the contexts of naval activity, shipbuilding, regional shipping, and industry patterns. A Bureau of Land Management "Summary and Analysis of Cultural Resource Information on the Continental Shelf from the Bay of Fundy to Cape Hatteras," (Bourque,1979) identifies the Delaware Coastal Zone as an area of "moderately heavy" predicted shipwreck density and acknowledges the potential for inundated prehistoric archaeological sites.

3.10.2 Nearshore Sand Borrow Areas

Based on the moderately high probability for both prehistoric and historic cultural resources in the potential sand borrow areas, the Service contracted Dolan Research, Inc. to conduct a Phase I underwater archaeological investigation to assess the three potential borrow areas for cultural resources. No potentially new significant magnetic or sonar anomalies were suggestive of submerged cultural resources and no relict landforms with potential for intact prehistoric archaeological potential were found (Cox, 2014).

3.10.3 Terrestrial Existing Conditions

Prehistoric Cultural Context Overview
For the purposes of completing a prehistoric overview of the project areas, various publications by Jay Custer of the University of Delaware's Center for Archaeological Research (1984, 1989) have provided a suitable general context.

The prehistory of the Delaware River Valley is divided into chronological time periods. Each period groups similar sets of cultural adaptations to environmental, and inferred social stresses as interpreted from archaeological data. Cultural adaptations including, settlement/subsistence patterns, resource utilization and exchange/trade networks, change through time and often by region. Symptoms of cultural adaptations are manifest as artifacts, food debris, burials, and features. Periods, therefore, are further divided into complexes that specifically describe adaptations through time or between physiographic zones.

There are four cultural periods generally recognized by Custer (1984) for the Delaware River Valley; Paleo-Indian (c. 14,000 B.P. to 8,500 B.P.), Archaic (c. 8,500 B.P. to 5,000 B.P.), Woodland I (c. 5,000 B.P. to A.D. 1,000), and Woodland II (c. A.D. 1,000 to A.D. 1,600). Each period corresponds to environmental episodes that were marked by broad climatic changes, thereby affecting the productivity and distribution of environmental resources available to people over time. This chronology can be applied to both terrestrial and maritime settings.

Historic Cultural Context Overview
The first European settlement along the Delaware River occurred in 1623 when Dutch Captain Cornelis Mey established a trading fort at Fort Nassau, now Gloucester, New Jersey. In 1629, Holland granted land at Cape Henlopen to S. Blommaert, S. Godyn, and David deVries. Two years later, Captain Peter Heyes with 28 men established a trading fort at Zuaanaendael, now Lewes. In 1638, Swedes established Fort Christiana in New Castle County. By 1654, New Sweden had only 368 settlers mostly living near the head of Delaware Bay. The next year, Peter Stuyvesant, Dutch Governor of New Amsterdam, attacked and captured the Swedish settlements. In 1658 the dutch reestablish the trading post at Hoornkill River, now Lewes. In 1680, Sussex County was formed and by 1690 the system of "Hundreds" was organized for voting, taxes and lad administration. Cedar Creek Hundred and Broadkill Hundred include areas of the refuge.

The 18th century was a period of agricultural expansion and population growth in the American colonies. As the ports of New Castle, Wilmington, and Philadelphia grew to major urban centers, agriculture diversified to production of grains. Sawmills and gristmills became common rural industries as roads developed to exploit forests and produce from interior farms. Route 16, Prime Hook Road, and Slaughter Beach Road might have been developed during this period.

Archaeological evidence for 17th and/or 18th century archaeological sites at the refuge is scarce. At the Morris Mansion Site (USFWS Archaeological Site Number PMH-020H), perhaps the home of John

Conwell, Sr., the recovery of Delftware, lead-glazed earthenware, Creamware and German Stoneware suggests an early Colonial occupation. However, the sample of diagnostic artifacts was not large and testing was not sufficient to verify the historical location of a colonial structure. Other archaeological sites possibly dating to the 18th century include the Island Farm Site (PMH-002), the Hazzard Landing site (PMH-003H), the Wall Island site (PMH-042H), and the Field 401 West Area site (PMH-038H) (Marshall, 2004).

The 19th century marked the apex of rural agricultural development in Delaware. Census records provide detailed information about ethnicity, age, sex and after 1850, information about professions and economic status.

Most of the farms historically located on the refuge have been identified as archaeological sites. Nineteenth century archaeological sites include the Captain William Conwell Farm site (PHM-006H), R. Morris Farmstead site (PMH-007H), the Tract 80 Graveyard site (PMH-008G), John Conwell Farmstead site (PMH-009H), the John T. Conwell Farmstead site (PMH-010H), the Arthur Piper Farmstead site (PMH-011H), the Mid-State Homes, Inc. House site (PMH-012H), the Daw's Farmstead site (PMH-018H), the Morris Graveyard site (PMH-019G), Morris Mansion site (PMH-020H), the Waples Mill Tailrace site (PMH-023H), the David Naylor Wells Farmstead site (PMH-024H), the Martin Farmstead site (PMH-025H), the George Wilson Farm site (PMH-026H), the B.P. Waples Farmstead site (PMH-027H), the Elwood Stevenson Farmstead site (PMH-028H), and the Dr. Joseph Maull Farmstead site (PMH-034H).

There are 45 terrestrial archaeological sites recorded within the APE. These include 14 prehistoric archaeological sites and 31 historic archaeological sites. Historic sites include 2 historic cemeteries. No historic architectural resources have been preserved. Three archaeological sites have been recommended as eligible for the National Register of Historic Places (NRHP), including the prehistoric Teacup Island site (PMH-022P), the Oak Hill site (PMH-032P), and the historic site of the Morris Mansion (PMH-020H) (Marshall 2004). The NRHP eligibility status of most of the other sites is currently undetermined.

3.10.4 Dune and Beach Berm Construction

The selected plan involves the placement of sand along a 6,375 linear feet of shoreline within the refuge's Management Unit II. No historic properties that are possibly eligible for (or listed on) the NRHP are found in this section of the project.

3.10.5 Wetland Restoration

The proposed excavation of 30 total miles of existing channels within the tidal wetlands of Units II and III with thin layer side casting, and the removal of approximately 1,800 linear feet of fill that form the roadbed of Fowler's Beach Road are within areas of previous disturbance. No new channels are planned for excavation and all archaeological sites located during previous investigations (Tirpak and Thomas, 1981; Marshall, 2004) are located within the uplands and on islands within the marsh, and not within the areas to be excavated for the proposed undertaking.

3.10.6 Access Points and Staging Areas

The undertaking requires the use of three staging areas (Northern, Central, and Southern) within the APE. The Northern staging area is within an agricultural field with a gravel road for access; the Central staging area is an open field currently used for parking; and, the Southern staging area is to be used as an access point for dredged material allocation. None of these areas have been assessed for cultural resources;

however, steps will be made to protect each area from subsurface impacts whether through the use of timber matting or temporary geotextile and gravel covering.

3.11 Socioeconomic Environment

Delaware is 96 miles long and varies from 9 to 35 miles wide. Chief products are manufacturing, mining, fish industry, and agriculture. Delaware ranks 5th in the nation in percentage of cropland, with a total of 39 percent of State lands cultivated (Atkins, 2012) and leads the nation in the percentage of protected farmland through agricultural easements.

Prime Hook NWR is located 12 miles southeast of the town of Milford in Sussex County and 10 miles northwest of the town of Lewes, where the Delaware Bay mouth meets the Atlantic Ocean. Numerous seaside resorts and small towns surround the refuge. Half of Delaware's 25 miles of coastal beach habitats are State Parks. Tourism in Sussex County employs over 10,000 people with abundant beaches, marinas, inland bays, quaint historic towns, and golf courses. National wildlife refuges enrich people's lives in a variety of ways, and ecotourism derives many monetary and quality of life benefits from the conservation of wildlife and natural habitats.

Caudill and Henderson (2005) evaluated the economic benefits of the refuge to local communities, which represent the economic value of the refuge before the onset of marsh degradation. Prime Hook NWR visitors do not pay entrance fees to visit, however, the State requires the purchase of hunting and fishing licenses. Visitors obtain services and purchases from local businesses for food, lodging, and other area recreational services. The location of the refuge in Sussex County is within driving distance of large urban areas including Washington, DC, Philadelphia, and Baltimore. In 2004, the refuge had 106,525 visitors. Table 3-6 quantifies the local economic effects associated with recreational use of the refuge in 2004. These values represent employment income, tax revenue dollars, and the impact of ecotourism within the three county area by Prime Hook NWR visitor spending. Numbers of annual visitors to the refuge has continued to climb since 2004.

Table 3-6: Local economic effects associated with 2004 recreational visits.

	Residents	Non-Residents	Total
Final Demand	$346,000	$1,110,200	$1,456,600
Jobs	3.0	9.8	12.8
Job Income	$ 99,400	$ 320,000	$ 419,400
Total Tax Revenue	$ 69,700	$ 221,300	$ 291,000

The total economic effects relative to the Prime Hook NWR operating budget for 2004 was also evaluated by Caudill and Henderson (2005). Net economic value is defined as an individual's willingness to pay for a particular recreation activity minus the person's actual expenditures for that activity. The figure for economic value is derived by multiplying net economic values for hunting, fishing, and non-consumptive recreation on a per day basis by estimated refuge visitor days for that activity and combining that number with the estimate of total expenditures, and dividing by the refuge budge for 2004. Caudill and Henderson (2005) estimated that for every $1 of refuge budget expenditures, $1.85 of total economic effects are derived by refuge visitation (Table 3-7).

Table 3-7: Recreation expenditures and economic effects for the Prime Hook National Wildlife Refuge.

	FY 2004 Budget	Recreation Expenditures	Net Economic Value	Total Economic Effects per $1 Budget Expenditure
Prime Hook NWR	$1,290,700	$1,043,600	$1,344,400	$1.85

Sexton *et al*. (2007) reported visitor and community attitudes and preferences by way of surveys (1,859) for visitors to the refuge and area residents. Most refuge visitations are by repeat visitors, about 72 percent of total visitors were from the local area. Wildlife observation was listed as the primary reason for both groups of visitors. Consumptive users primarily engaged in hunting (80 percent) and fishing (30 percent) and non-consumptive visitors engaged in the following activities: bird-watching (73 percent), nature/wildlife viewing (64 percent), hiking/nature trails (56 percent), and special educational events and tours (collectively 68 percent). Both residents and non-resident visitors alike expressed strong support for the services and features of the Prime Hook NWR.

3.11.1 Environmental Justice

Demographic data ranks Delaware's human population (830,364) as 45th in the nation. Sussex county residents are predominantly Caucasians not of Hispanic origin (U.S. Census Bureau). The poverty rate in 1997 was 9.7 percent. In 2000, more than a quarter of all Sussex County homes were occupied for seasonal or recreational use.

3.12 Air Quality

The Division of Air Quality and Waste Management within DNREC monitors levels of ozone and particulate pollution from nine locations within the State. The Lewes monitoring station is the closest to the refuge and has been monitoring air quality since the 1960s. The EPA has established national ambient air quality standards (NAAQS). There are currently seven criteria pollutants: sulfur dioxide, nitrogen dioxide, carbon monoxide, ozone, lead, particulate matter less than 10 microns in diameter (PM10) and particulate matter less than 2.5 microns (PM2.5). Local air quality is affected by regional sources. In general, air quality in Sussex County is good during the winter and spring, but only fair in summer and fall. Sussex County is more heavily populated during the summer and early fall seasons due to its many beach resorts, and is often in non-attainment for NAAQS air quality standards.

3.13 Hazardous, Toxic, and Radiologic Wastes

Hazardous, toxic, and radioactive wastes (HTRW) are defined as any "hazardous substance" regulated under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), 42 U.S.C. 9601 *et seq*., as amended. Hazardous substances regulated under CERCLA include "hazardous wastes" under Section 3001 of the Resource Conservation and Recovery Act (RCRA), 42 U.S.C. 6921 *et seq*., "hazardous substances" identified under Section 311 of the Clean Water Act, 33 U.S.C. 1321; "toxic pollutants" designated under Section 307 of the Clean Water Act, 33 U.S.C. 1317; "hazardous air pollutants" designated under Section 112 of the Clean Air Act, 42 U.S.C. 7412, and "imminently hazardous chemical substances or mixtures" that the EPA has taken action on under Section 7 of the Toxic Substance Control Act, 15 U.S.C. 2606. An HTRW literature search was conducted for the vicinity of Broadkill Beach by the Philadelphia District USACE (1996). The database identified the Broadkill

Beach Fire Control Station as a site of potential concern. Although there may be a potential for ordnance, unexploded waste, or chemical materials associated with the Fire Control Station historical operations, the possibility for the proposed project north of Broadkill Beach to encounter HTRW is low. Based on the grain size of the majority of the material located within the nearshore borrow areas, there is little potential for contamination to the project site or vicinity.

3.14 Noise

Activities within the refuge typically do not generate significant noise. Activities include fishing and crabbing, hiking, dog walking, horseback riding, and bicycling. From September 1 through mid-April, various portions of the refuge are temporarily closed to the general public for deer, turkey, migratory bird, and waterfowl hunts. While bow hunting produces no noise, the use of firearms does generate the greatest noise levels of any refuge activity.

4.0 Environmental Effects

This section describes the environmental consequences anticipated for the proposed plans: (1) construction of the beach berm, dune, and back barrier wetland transition platform by the USACE; and (2) tidal circulation channel excavation by the Service. Environmental effects from the No Action Alternative are summarized herein for brevity. A complete evaluation of environmental effects for both the No Action and the alternative plans that were considered is provided in chapter 5 of the CCP/EIS, 2012. More analytical evaluations of those features of the selected plan that were developed subsequent to the completion of the CCP/EIS (2012) are provided below (*i.e.* for the borrow area evaluations, the final beach nourishment plan, back barrier wetland platform development, and interior wetland tidal flow channel excavation).

During and after the preparation of the CCP/EIS, major habitat changes continued to occur within the refuge as a result of beach breaching from storms and further tidal flooding and saltwater intrusion into former freshwater impoundments in Units II and III. The rapid introduction of seawater has killed freshwater vegetation, and to date, there exists a sediment deficit due to insufficient sediment influx (C. Sommerfield, pers. Comm.; Atkins, 2009). The sediment deficit within the Delaware Estuary have been attributed to a combination of actions that have occurred primarily in the upper reaches of the estuary, and include shoreline armoring, channel dredging and upland confined placement operations; and within the refuge itself: freshwater impoundment management. The refuge staff, in collaboration with State and university researchers, will continue to assess the biological, chemical, and geological impacts of these changes and establishing a baseline for assessing habitats post-project construction.

4.1 Geographic Setting

Under the No Action scenario, the increase in open shallow water area, shoreline erosion, flooding on neighboring farmland and residential areas, and loss of vegetated cover and wildlife habitat will continue to occur. The rate of erosion and landward migration of the refuge shoreline along Unit II from 1937 to 2012 was quantified with historic aerial images (DNREC DCP, unpub.; Psuty *et al*., 2010). The rate of erosion has accelerated from 3 feet a year between 1937 and 1954 to 10 feet a year between 1997 and 2012. Shoreline position has been monitored carefully on the ground every spring and fall since 2011. Between spring 2011 and spring 2014, the shoreline retreated about 9 meters in most areas, which represents a continued erosion rate of about 10 feet per year. However, the total shoreline retreat in many areas of the project area over that time was about 30 to 60 feet total, or up to 20 feet per year (Psuty *et al*., 2014). Currently, the total length of the eroded beach barrier and dune system extends from Fowler Beach Road to Prime Hook Beach and is approximately 6,000 linear feet.

More recently, the refuge's undeveloped barrier island habitats has become reconfigured geomorphologically after each coastal storm, making the beach more susceptible to storm overwash. The refuge's coastal and inland wetlands are recognized as an important ecological resource for waterfowl, wading birds, shorebirds, and aquatic species. Prime Hook NWR is geographically located in direct line with the Atlantic Flyway, a bird migration route stretching from South America through the Caribbean up to the northern Atlantic coast. Due to urban and industrial development over the last 60 to 80 years, nearly 40 percent of the Atlantic Flyway's bird species are species of conservation need (National Audubon Society), and the refuge provides an optimal stopover place for migrating birds.

The preferred plan entails the USACE restoring the barrier beach and dune system fronting the refuge with sand replenishment and established elevations for a wetland platform. Within the interior of the

refuge, the Service will re-establish tidal creeks within their historical footprint (*i.e.* prior to impoundment in the 1980s) to provide both a mechanism for sediment transport and marsh development. Studies have shown that increasing the amount of creek edge in a tidal marsh will increase the rate at which marshes mature (Tyler and Zieman, 1999).

4.2 Geology and Hydrology

The long-term success of tidal marsh establishment relies on many geological and biotic processes that contribute to vertical accretion of the vegetated marsh platform. A critical component of marsh development and expansion is a reliable supply of organic and mineral sediment to the system, which provides nutrients and substrate for vegetative growth. Sediments are delivered to the marsh via tidal channels and overwash events during storms when the tide water turbidity is highest. Under natural conditions, the tidal channels, flats, and marsh platform evolve together such that the flux of sediment through the channel network is sufficient to support accretion and marsh-surface elevation between mean tide level and mean high water (Sommerfield, pers. comm.). Within the prior freshwater impoundments, the organic fractions and clays, established over time under freshwater conditions and vegetation, degraded once they became exposed to saltwater inundation. Organic soils emulsified and tidally dispersed. Freshwater plants could no longer thrive and without vegetation, additional soil losses resulted from winds and tides. *Spartina* spp. saltmarsh vegetation has begun to re-establish naturally in areas where emulsified organic material has been carried by the tides and settled out in quiet cove areas and providing sufficient elevation. In areas where tidal flow continues to stack without sufficient drainage in between, sediment losses will continue to occur with elevations insufficient for vegetation to re-establish. This pattern has been documented through recent monitoring of surface elevation and vegetative changes at monitoring stations throughout Unit II. The Service recognized the need to close the beach breaches and lower the water levels within the former impoundments by removing the water control structures to allow for plant growth natural to the location.

The University of Delaware, in a collaborative effort with the Delaware Coastal Programs Section (DCP), is conducting a pre-project study on sediment-transport pathways and fluxes within the refuge, as they relate to tides, wind stress, and freshwater discharge. Critical to the wetlands ability to keep pace with SLR is an understanding of the site-specific hydrological net mass of sediment entering and exiting the Management Units. The sediment budget study will be used to construct a conceptual model of sediment supply to the refuge wetlands for the Service's ongoing restoration efforts and to provide baseline information for any adaptive management strategies until the marsh is self-sustaining.

Under the preferred plan, marine waters interfacing with the beach placement site display considerable daily variation in current conditions due to tides and wind. Any project-induced changes to the physical conditions within the restoration project area would ultimately improve the overall refuge habitat quality and improve the long-term sustainability of the back barrier environment. The hydrology of a natural tidal connection to the back barrier area will be restored to areas formerly impounded. The back barrier marsh platform has been designed to incorporate the existing shoals which have formed since the breaches occurred. Natural saltmarsh sediment chemical composition and vegetation will then re-establish in the easternmost areas of the refuge. Brackish and freshwater areas, predominately fed by Prime Hook Creek, will occur in more interior portions of Unit III and IV. Although larvicides and adulticides have been used on the refuge for mosquito control, Open Marsh Water Management (OMWM) is the State of Delaware's preferred method to control mosquitoes while reducing the need for chemical insecticide treatments. It is a method for controlling salt marsh mosquitoes through physical alterations of marsh habitats. Often, OMWM is applied in areas where historic grid-ditching was conducted in an attempt to restore features similar to natural pannes and channels in those areas while also controlling mosquitoes and creating habitat for fish. Such biological controls have been effective in

reducing mosquito production by 95 percent in treated areas (DNREC 2008) and the preferred plan supports this objective.

Atkins evaluated peak water levels within Units II and III of the refuge adjacent to the Prime Hook Beach and Broadkill Beach communities using measured data and the hydrodynamic modeling results. They looked at three scenarios: (1) existing conditions with removal of the water control structures; (2) beach breach closure and removal of the water control structures; and (3) the selected plan design of breach closure and conveyance channels in Units II and III. These scenarios were evaluated for water levels under both normal conditions of low frequency events (2013 to 2014 measured data) and water levels during the Hurricane Sandy (2012). Modeling demonstrated that closing the breaches, with or without adding the conveyance channels, will reduce peak water levels within the refuge, for both normal and storm conditions. Adding the conveyance channels will further reduce water levels along the Prime Hook Beach and Broadkill Beach communities (Appendix A).

4.3 Water Quality

Under the No Action scenario, inundation of flood waters into the refuge causes excessive erosion during storms, thereby, reducing water quality and clarity and exacerbated by further losses of vegetated land cover. Marsh vegetation has the capacity to improve and maintain water quality through filtration, nutrient uptake, and sediment trapping capacities. Within the refuge, the Service will partner with DNREC's DCP and the University of Delaware to conduct pre- and post-construction monitoring to update and continue water parameter sampling, collect flow and suspended sediment data, marsh elevation monitoring, and nekton sampling within the refuge's Management Units that contained former impoundments. The successful establishment of the tidal marsh plant community will support the wetlands' ability to keep pace vertically with SLR into the future and improve water quality by reducing erosion. DCP will support refuge staff in monitoring this process by measuring changes in marsh elevation and quantifying marsh surface accretion.

In cooperation with NOAA's National Estuarine Research Reserve System, DCP developed protocols for real-time water parameter monitoring and installed a water monitoring system in the refuge in 2010. Prior to the beach breach repair and wetland platform development, DCP will upgrade the system of data sondes and transmission. These sensors will collect surface water levels, salinity, temperature, and dissolved oxygen. Samples will be taken to assess water nutrient levels at various locations in the refuge. Fish usage will be investigated by tracking acoustically tagged key species, American Eel (*Anguilla rostrata*) and White Perch (*Morone Americana*), in the refuge and surrounding waters. The study will provide baseline information on movement and habitat use of fish within the refuge during current breach conditions and for long-term post-construction restoration condition.

Physical and biological impairments to water quality can result from the proposed project due to increases in turbidity from dredging and placement operations. Increased turbidity results from the resuspension of sediments during operations and is temporary, but can impact primary productivity and respiration of organisms in the immediate project area. Increased turbidity can also impact prey species' predator avoidance ability due to decreased clarity in the water column. Impacts to water quality may occur at both the beach and wetland platform placement areas, as well as during excavation operations to create interior circulation channels. Increased suspended sediment in the water can reduce dissolved oxygen (Johnston, 1981). This can be more of a concern during summer months when water temperatures are warmer and less capable of holding dissolved oxygen (Hatin *et al*., 2007). The nature, degree, and extent of the suspended sediment plume in the water is controlled by a variety of factors including sediment particle size, solids concentration, dredge type, discharge rate, water temperature, and hydrodynamic forces (*i.e.* waves, currents) causing horizontal mixing (USACE, 1983).

Dredge draghead movement can create a turbidity plume in the bay at the borrow area. Turbidity levels decrease exponentially with increasing distance from the dredge due to settling and dispersion. Plume concentrations, particularly when the material is predominantly large grained sand particles, is expected to return to background levels quickly in most cases. The vast majority of resuspended sediments resettle close to the dredge within one hour (Anchor, 2003). Overall, water quality impacts are anticipated to be minor and temporary.

A Section 401 Water Quality Certificate under the Clean Water Act of 1977 (PL95-217), as amended, is required from the State of Delaware, and a Department of the Army permit under Section 10 of the Rivers and Harbor Act and under Section 404 of the Clean Water Act are required for the proposed project. Pursuant to Section 404 of the Clean Water Act, the impacts associated with the discharge of fill material into waters of the U.S. are discussed in Section 7.0 (404(b)(1) Guidelines Analysis.

4.4 Beach and Intertidal Habitat

Under the No Action scenario, beach and intertidal habitat would continue to be lost due to tidal flooding and inundation and conversion of interior wetlands to open water and barren mudflats. Under the preferred plan, placement of sand at the designated beach nourishment site and graded to profile will be conducted to construct the berm and repair all of the breaches. Fine particles that may be present in the sand will be transported and dispersed in the swash zone. Dredging with a pipeline (*i.e*. hydraulic) minimizes the amount of material re-suspended in the water column both at the borrow site location as well as during transport to the placement site in a pipe. Dredge material removed from the borrow area will travel a distance of 0.85 to 2.1 miles through the pipe to the beach placement site. Sections of pipe lying on the bay bottom would cause a small area of disturbance to the benthic habitat and finfish resources, but these impacts will be avoided by floating the pipe on pontoons.

Discharge of the sand slurry at the placement site affects a small area and is considered minor, localized, and temporary. Discharge can result in suspended sediment levels as high as 500 mg/L within 2,050 feet of the disposal site and decreasing to background levels within 1,000 to 6,500 feet (USACE, 1983). Localized turbidity in the nearshore environment is dependent upon the type of fill, which will be predominantly sand with minimal turbidity impacts to biological resources. The borrow material is comprised of medium to fine beach quality material compatible with the existing grain size on the placement site, thereby reducing the duration of elevated localize turbidity (Greene, 2002). This view is supported by a review by the Atlantic States Marine Fisheries Commission that evaluated biological and physical impacts of beach nourishment studies showing turbidity plumes and elevated Total Suspended Solids (TSS) levels drop off rapidly seaward of the sand placement site.

Wilber *et al*. (2006) evaluated the effects of a beach nourishment in a much higher energy environment along the ocean coast of northern New Jersey and reported maximum bottom surf zone and nearshore TSS concentrations related to nourishment activities of 64 and 34 mg/L, slightly higher than background maximum bottom TSS concentrations in the nearshore zone of unnourished portions of the beach. Additionally, Wilber *et al*. (2006) reported that elevated TSS concentrations associated with active beach nourishment were limited to 400 meters (1,310 feet) from the discharge pipe in the swash zone. Other studies found the turbidity plume and elevated TSS levels are expected to be limited to a narrow area of the swash zone up to 500 m (1,640 feet) down current from the discharge pipe (Schubel *et al*., 1978; Burlas *et al*., 2001). Recent monitoring of suspended sediment (TSS concentrations) at locations throughout the refuge wetlands demonstrate a wide variation in TSS conditions presently. In the vicinity of the project area near the breaches, concentrations ranged from 30 mg/L to 478 mg/L, averaging about

150 mg/L (Scarborough *et al*., unpubl. data). Based on these studies, turbidity levels created by beachfill operations along the shoreline are unlikely to differ considerably from existing conditions.

Minimal adverse impacts are expected to occur at the placement site as the area is already severely eroded with large areas of exposed peat and of poor quality habitat value. The intertidal zone is a dynamic higher-energy area, subject to the forces of wind and waves. Under natural conditions along a sandy beach, sand normally moves offshore in the winter and returns on-shore in the spring and summer. After beach nourishment, sand will redistribute to a more stable profile (NRC, 1995). Following sand placement, there are notable physical changes to a nourished beach. For example, sand is more compacted along a nourished beach, sometimes three to four times higher, which has been shown to increase over time for some beaches (Ryder, 1991). The upper beach zone will be planted with American beach grass (*Ammophila breviligulata*), a pioneer species in natural dune formations due to its extensive root and rhizome system.

Other physical changes from placement of sand may include increased shear resistance (sand permeability), altered dry density, change in moisture content, slightly different grain size, and silt/clay composition changes (Parr *et al.*, 1978; Reilly and Bellis, 1983; Nelson and Dickerson, 1988; Ryder, 1991). Such sediment may cause changes in the hydrodynamic patterns in the intertidal zone. The material available in the proposed borrow area is compatible with existing beach sand and the majority of the available material has a low quantity of silt. Temporary elevated turbidity in the immediate placement area are expected to be minor and brief. One positive impact is to down-drift beaches receiving sand moving alongshore from the nourished beach.

4.5 Vegetation and Land Cover

Changes in vegetation (and habitat) in saltmarshes along the northeastern coast of the U.S., including Delaware, have resulted from historic management practices (Niering and Warren, 1980; Roman *et al*., 1997). The Dutch and English settlers practiced reclamation of saltmarshes for meadow impoundments in the 1800s (Weinstein *et al*., 2000) and ditching and draining practices for mosquito control was conducted beginning in the early 1900s (Adamowicz and Roman, 2002). Most recently, storms have had the most profound impacts on the coastal shoreline.

The State of Louisiana has conducted substantial restoration efforts along its shoreline (Atkins, 2014). Since the 1990s, the loss of barrier islands has been attributed to inadequate sediment supply and lack of a stable, above-water back barrier platform upon which barrier islands can migrate landward in response to SLR, reduced sediment supply, and storm impacts (McBride and Byrnes, 1997). Under natural conditions, the beach/dune/saltmarsh system is resilient to SLR if an adequate sediment supply and an appropriate back barrier wetland platform exist. Sallenger *et al*. (2010) showed that extensive erosion of the marsh platform of Chandeleur Island on the Gulf Coast compromised the stability of the system, and migration of the shoreface will continue to erode the marsh platform (Moore *et al*., 2010), substantially converting existing marsh vegetation to mud flats and open water.

Storm overwash and natural processes resulting in breach closures serve to maintain the barrier beaches as they migrate landward in response to SLR, maintaining marsh vegetation as it migrates landward (Godfrey, 1976; Dolan, 1972; Leatherman, 1979; Goldsmith, 1985). In the absence of an adequate sediment supply, sand renourishment and back barrier platform development is needed to offset impacts for moderate to long-term restoration efforts (McBride and Byrnes, 1997). Penland *et al.* (2004) showed nourishment, dune construction, and back barrier marsh creation as the only efforts that built new land and reversed Gulf shoreline erosion. Armbruster (2000) documented how vegetation plantings along the dune and beach flat and marsh platform restored sustainable barrier island plant communities while

stabilizing the surface. In Virginia, the absence of back barrier marshes on the southern part of Metompkin Island is believed to increase the rate at which dunes migrate in comparison to the island's northern half where substantial marsh is present (Brenner and Moore, 2010). Studies along the Delmarva barrier island chain by Kraft *et al*. (1976) emphasize the importance of overwash deposits of sediments to maintain the system.

Under the No Action scenario, the refuge would continue to incur losses of acreage and vegetated habitat as it is converted to open water and mudflats. Recovery of tidal marsh vegetation would be limited to small areas where sufficient elevation exists, primarily on the periphery of the impoundments. Under the preferred plan, natural hydrologic circulation will be reintroduced to the system in a more controlled manner through the creation of tidal channels. The appropriate rate of tidal flow is conducive to the re-establishment of salt marsh vegetation to that which occurred previous to impounding. In additional to providing natural coastal habitat, saltmarshes serve to provide more resiliency to storms along the coastline, thereby providing further protection for valuable habitat within the interior of the refuge's 10,144 acres.

The preferred plan includes planting beach grass along the dune face and back berm and *Spartina* on the back barrier wetland platform. Beach flora are adapted to the harsh conditions typical of beaches: low fertility, heat, and high energy from wind. The dominant plant on these dunes, American beachgrass (*Ammophila breviligulata*), is tolerant of salt spray, shifting sands and temperature extremes. With the establishment of adequate beach berm elevations, beachgrass is instrumental in the development of dune stability, which opens up the dune to further colonization of stabilizing plants such as seaside goldenrod (*Solidago sempervirens*), sea-rocket (*Cakile edentula*), and beach cocklebur (*Xanthium echinatum*). The Delaware Bay coastline has long been recognized as one of the most important and critical shorebird stopover in the Western Hemisphere. The refuge's undeveloped barrier beach berm habitats are important to both migrating and breeding shorebirds in the face of beach development.

The reduction in coastal flooding will allow for plant communities and their associated wildlife to regain a healthy diverse assemblage within the brackish and freshwater interior areas of the refuge. Exemplary natural communities found at the refuge include rare plants such as purple pitcherplant (*Sarracenia purpurea)*, round-leaf sundew (*Drosera rotundifolia*), fibrous bladderwort (*Utricularia fibrosa*), and southern bladderwort (*Utricularia juncea*). In addition, a subspecies new to the flora of the State of Delaware and the Delmarva Peninsula was found on the refuge: bushy bluestem (*Andropogon glomeratus* var. *hirsutior*). Other rare flora in the interior refuge that will benefit from increased storm protection and resiliency of the coastline by the proposed project include present a swamp environment of standing water with a shrub layer of species such as water willow (*Decadon verticillatus*), sweet pepperbush (*Clethra alnifolia*), and southern bayberry (*Morella caroliniensis*). Management Unit III possesses the largest known population in the State of lance-leaf orange milkweed (*Asclepias lanceolata*). A Coastal Bayshore/Succulent Bush community is found in Management Unit IV and dominated by sea purslane (*Sesuvium portulacastrum*) and panic beachgrass (*Panicum amarum*). This community is not known to occur anywhere else in Delaware. For a more detailed listing of rare plants found within the refuge, refer to chapter 3 of the CCP/EIS (2012).

Salt marsh communities along the East Coast are the most degraded of all wetland habitats, and within the mid-Atlantic region a substantial number of salt marshes have been lost or degraded in the last century (Kennish, 2001). With the loss of greater than 50 percent of these habitats in the Mid-Atlantic, remaining salt marsh areas are critically important for many salt marsh-dependent species that are experiencing major population declines. It is anticipated that less than 0.5-acre of saltmarsh vegetation will be impacted at the transition zone from landward berm to back barrier wetland platform. To facilitate re-colonization of salt marsh vegetation and to stabilize the newly constructed beach barrier marsh platform,

the preferred plan will include an active management strategy to plant up to 60 acres of *Spartina alterniflora* (lower platform) and *Spartina patens* (upper platform) along the back barrier of Unit II. Passive management strategies will then be utilized for the remaining mudflat and open water areas of Unit II and Unit III, which include allowing natural processes to occur within the areas of dune/beach berm and grassland system and the existing successional maritime salt shrub and maritime forested woodland habitats, and the conversion of mudflat and open water to *Spartina* and irregularly flooded eastern tidal salt shrub habitat. The restored saltmarshes will provide protection to the more interior freshwater regions and upland mature forest.

4.6 Marine Resources

The impacts of dredging operations on marine organisms are dependent on the type of dredge used. A hopper dredge is a vessel equipped with propulsion machinery, a sediment containers (*i.e.* hopper), dredge pumps, and other specialized equipment required to excavate sediments from the seabed. A hopper dredge removes material from the bottom in thinner layers than a hydraulic dredge, depending on the density and cohesiveness of the dredged material and once full, the vessels travels to the placement site. A hydraulic cutterhead pipeline dredge is a barge hull with a moveable rotating cutter apparatus surrounding the intake of a suction pipe (Taylor, 1990). By combining the mechanical cutting action with the hydraulic suction, the hydraulic cutterhead has the capability of efficiently dredging a wide range of material, including clay, silt, sand, and gravel. These dredges are capable of pumping material through as much as 5 to 6 miles of pipeline. For the proposed project, the distance from the preferred borrow area to the placement site is less than 2 miles. The use of a hopper dredge would not be feasible for the proposed project, given shallow depths and the short distance from the borrow area to the beach. Hopper dredges also require double handling of the material, increasing habitat impacts and operational costs, while the cutter suction head dredge would dredge and then discharge directly to the beach. The NMFS advises minimizing the use of hopper dredges in favor of cutterhead dredges.

4.6.1. Borrow Area Sediments

Borrow Area BHP-B is the preferred borrow area due to its proximity to the placement location (Figure 4-1). It is also the largest delineated site of the three identified borrow area alternatives. Borrow Area PHB-B possesses fine-grained silty material in the northern portion of the site that is preferred for placement on the back barrier marsh platform for plant establishment. The proposed dredging plane would require a dredging depth limit of -5 feet to reduce the potential for environmental impacts to benthic organisms and fish. With a dredge cut limit, the likelihood of a change in bottom substrate type is reduced and also avoids the creation of deep pits that are conducive to anaerobic conditions. Material best suited for construction of the beach berm, dune, and back barrier marsh platform would be sand that is closely compatible with existing beach sand.

Dredging operations can mitigate impacts to sediments within the borrow area by creating ridges (*i.e.* maximum shallow dredging depth) as opposed to large and deeper depressions, which allow for quicker benthic community recruitment from neighboring unimpacted areas. Benthic organisms recover more quickly after dredging operations cease when the sediment substrate is not significantly altered. Boring data reveals that the majority of the 845-acre borrow site possesses sand thickness greater than 5 to 14 feet. Post construction studies conducted for beach nourishment projects have concluded that the effects of beach fill operations on short-term turbidity appeared to be limited to the immediate area of the operation, and total suspended sediment concentrations outside the swash zone seldom exceed 25 milligrams per liter, a value comparable to concentrations many species regularly experience in estuaries.

Established dredging procedures will limit dredge cuts to no more than 5 feet below current elevations to minimize geomorphological impacts to the bay bottom. Dredge cut depths vary depending on the type of dredge plant utilized. Large hydraulic cutter suction dredges typically cut lanes approximately 200 feet wide and about 5 feet deep with each pass. It is anticipated that a smaller hydraulic cutterhead dredge will be used for this project due to shallow water depths and the nearshore location of the borrow area (*i.e.* approximately 150 feet wide cuts).

Seabed filling typically occurs following dredging events due to natural current processes and storms. The borrow areas are in relatively shallow water (*i.e.* 8 to17 feet) and the bay in general, due to its geomorphology is subject to wind-driven currents. Post-dredging bathymetric surveys are anticipated to demonstrate no substantial changes in borrow area sediments relative to pre-dredging conditions.

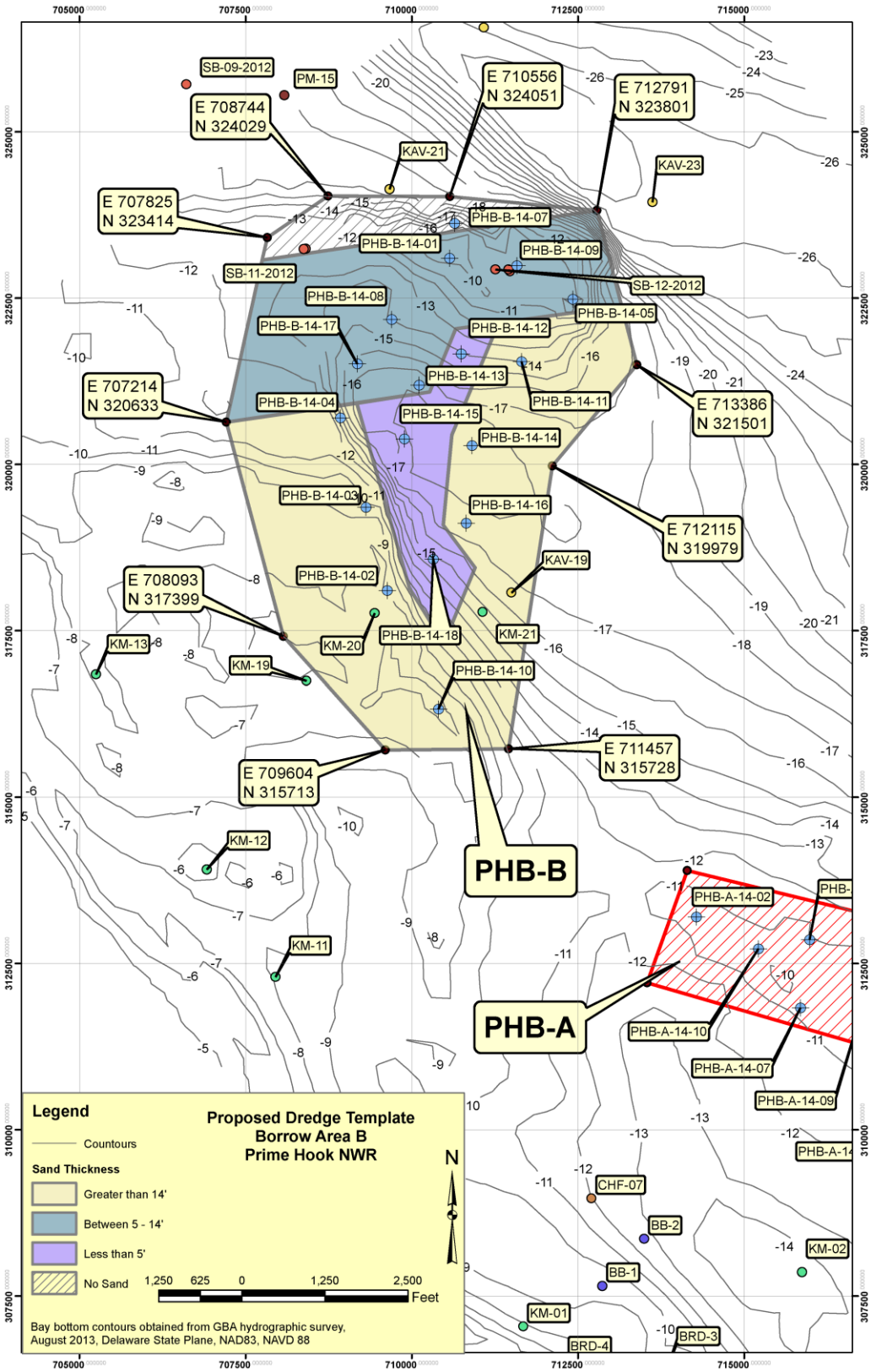


Figure 4-1: Vibracore locations and sand depths for Borrow Area PHB-B.

4.6.2 Benthic Invertebrates

Under the No Action scenario, low quality intertidal habitat would continue to exist at the placement site due to severe erosion and exposed peat. With the preferred plan that entails dredging and placement operations, infaunal organisms within the placement zone will be impacted by burial. Most of the organisms inhabiting these dynamic zones are highly mobile and respond to stress by displaying large diurnal, tidal, and seasonal fluctuations in population densities (Reilly and Bellis, 1983). The material will be pumped onto the beach above the mean high water line, thereby minimizing impacts to intertidal infaunal organisms. Despite the resiliency of intertidal benthic fauna, the initial effect of beachfill will result in some mortalities of existing benthic organisms. The ability of a nourished area to recover depends on grain size compatibility of the material pumped on the beach (Parr *et al*., 1978). Macrofaunal recovery is usually rapid after pumping operations cease. Recovery of the macrofaunal community may occur within one or two seasons because borrow material grain sizes are expected to be compatible with natural beach sediments. Results obtained from the intertidal and surf zone of Folly Beach, South Carolina, indicated that beach nourishment had a very brief effect on the infaunal abundance and number of species in the benthic communities (Lynch, 1994). Recolonizing infauna was observed in substantial numbers one day after nourishment. The abundances and species assemblages were generally not different from pre-nourishment samples after 3 months. Recolonization depends on the availability of larvae, suitable conditions for settlement, mobile organisms from nearby beaches, vertical migration of organisms through the placed material, and mortality. The benthic community can, however, be somewhat different from the original community.

At the proposed borrow area, the primary ecological impacts of dredging is removal of existing benthic organisms. This has an immediate localized effect on the benthic macroinvertebrate community. Survival of organisms during dredging varies widely (Peterson *et al*., 2000). Mechanical disturbance of the substrate generates suspended sediments and increase turbidity near the dredging operation and results in reduced light penetration temporarily. In addition to the physical disruption of the habitat, recolonization of the benthic community can be rapid, typically taking from a few months to a few years (Brooks *et al*., 2006; Maurer *et al*., 1981a,b; 1982, Maurer *et al.*, 1986; Saloman *et al*., 1982; Van Dolah *et al*., 1984). Recovery of infaunal communities after dredging has been shown to occur through larval transport, along with juvenile and adult settlement, but can vary based on several factors including seasonality, habitat type, size of disturbance, and species' life history characteristics (*e.g*., larval development mode, sediment depth distribution) (Shull, 1997; Thrush *et al*., 1996; Zajac and Whitlatch, 1991). Initial recolonization is dominated by opportunistic taxa whose reproductive capacity is high, and flexible environmental requirements allow them to occupy disturbed areas (Boesch and Rosenberg, 1981; McCall, 1977).

Highly mobile organisms, such as amphipods, can escape to the water column and can directly resettle after dredging operations are completed (Conner and Simon, 1979). Mobile polychaetes are intermediate of amphipods and bivalves in their capacity to resettle directly after dredging. Bivalves are the least mobile organisms, although pelagic larvae of these species can result in high recruitment. Larval recruitment and horizontal migration from adjacent, unaffected areas initially recolonize the disturbed area (Van Dolah *et al*., 1984; Oliver *et al*., 1977). Anderson *et al.* (2010) evaluated benthic organisms within Delaware Bay relative to major physical habitats of the seafloor, such as depth, sediment size, topography, and salinity. Salinity and sediment type were primary factors in benthic species composition. Annelids were the predominant benthic species inhabiting the project area as well as the Delaware Bay as a whole. Some benthic studies have demonstrated only subtle changes in sediment characteristics with a slight shift in corresponding benthic community composition post-dredging (Scott, 2012). No long term effects are expected as salinity would not change and the benthic community that naturally exists in the

area is present throughout the middle and lower bay region and dominated by species with opportunistic life histories that exhibit rapid recruitment capabilities.

Blue crabs. Adult blue crabs migrate to higher salinity waters of Delaware Bay in the December through March timeframe to overwinter. The crabs burrow into sediments of the deep channel as water temperatures decline and are not likely to be in the shallow waters of the project area during the cooler months of the year when dredging is proposed. During warmer months of the year, blue crabs are active within the shallow waters of the bay, but crabs in between molts have the mobility to move out of the area of disturbance at the dredge site.

Horseshoe crabs. Shallow water intertidal flats of Delaware Bay are prime spawning habitat for horseshoe crabs. Shallow water areas with low wave action and sand or mud substrate are also important nursery areas for juvenile horseshoe crabs for their first 2 years. Horseshoe crab eggs and larvae are a food source for migratory birds and several fish species. The use of seasonal windows will reduce adverse effects to horseshoe crabs by avoiding dredging during the spring and summer seasons when horseshoe crabs are most numerous in the shallow inshore areas. Beach nourishment will provide improved habitat for horseshoe crab spawning along the beach face.

Sabellaria. Previous studies were conducted on the effects of beach nourishment on *S. vulgaris* reefs and aggregations at nearby Broadkill Beach and Slaughter Beach, along with the effects of a storm event at Fowler Beach (Brown and Miller, 2011). At both locations, the placement of sand for the beach nourishment projects buried and killed *S. vulgaris* reefs. Once tidal currents eroded sand away and reef structure was exposed, new aggregations began to form in the following recruitment season. Following multiple recruitment seasons, the aggregations expanded to form reefs similar in size to those present before beach nourishment activities. A nor'easter storm in May 2008 destroyed large platform reefs at Fowler Beach but reefs were again observed in November 2008, but had shifted slightly south of the pre-storm location. Brown and Miller (2011) concluded that physical properties and nearshore bathymetry determined the location of reefs and aggregations. Beaches that faced northeast, have a narrow nearshore region to the 2-meter depth contour, and subject to large wind fetch distances had Sabelliid reefs while beaches which faced east, had larger distances to the 2-meter isobaths and less fetch had no reefs, and either some or no aggregations of *S. vulgaris*. Brown and Miller (2011) concluded that there is natural variation in recruitment among years that affects the persistence of intertidal *S. vulgari*s and year-to-year variations in settlement timing is one contributing factor in determining long-term growth and decline of reef structure. Reefs at Slaughter Beach, Fowler Beach, and Broadkill Beach were observed to recover after beach nourishment and disturbance from storm events within 1 to 3 years. Bottom surface substrate and benthic species mapping (Anderson *et al*., 2010) show the preferred borrow area (PHB-B) in an area with predominantly fine to medium grained sands and no gravel component. The likelihood of *Sabellaria* colonizing the borrow area is low as the species requires gravel for tube building (B. Wilson, pers. comm.).

In August 2014, Versar, Inc. conducted a benthic assessment of the three borrow areas PHB-A, PHB-B, and PHB-C targeted as potential sand sources for the proposed plan (Scott, 2014). Sediment and biomass analyses were conducted for 56 benthic samples collected. The benthic samples collected from the three borrow areas contained a community based on the sediment and salinity type within the lower estuary. The majority of the stations sampled in the three borrow areas had predominantly clean sand (*i.e.* very little silt/clay) and at these sites benthic species with an affinity for sand, such as haustorid amphipods and the small tanaid crustacean *Tanaissus psammophilus*, were prevalent. Sample locations that had predominantly sandy sediments with some silt/clay particles had higher numbers of species such as the polychaete *Mediomastus ambiseta* and the gastropod *Acteocina canaliculata* typical for silt/clay substrates. Additionally, species common to the lower estuary salinity regime, such as polychaete worms

Heteromastus filiformis, *Streblospio benedicti*, and *Neanthes succinea*, were present at many of the sampling sites within the three borrow areas but in low numbers.

The community attributes documented within the three borrow areas were neither unique nor rare so it is expected that all of these sites would quickly recover from dredging operations for shoreline nourishment activities. The majority of the taxa collected in both count and species have life history attributes that would allow them to quickly recover from dredging operations either by recruitment of new juveniles or by mobile adults from nearby undisturbed areas. Commercially valuable species, such as the surf clam *Spisula solidissima* and the hard clam *Mercenaria mercenaria*, were present in extremely low numbers at only a few sites. The ecologically important sand reef building worm, *Sabellaria vulgaris*, common to some lower Delaware Estuary shorelines, was not present within the three targeted borrow areas with the exception of two specimens collected from one site in Area PHB-C.

A trawl survey of epi-benthic species was conducted at a sub-set of 5 stations from the 17 benthic sampling locations in Areas PHB-A, PHB-B, and PHB-C. A 2-foot oyster dredge was towed for between 2 to 5 minutes at each station. Nine taxa were collected during the tows but no large commercially important clams or oysters were collected from any of the tows (Table 4-1). The knobbed whelk was the most abundant species collected and was found at 11 of the 15 sampling stations. There was no evidence of large colonies of the sand reef building worm *Sabellaria vulgaris* in any of the borrow areas (in either the epibenthic tows or the benthic grab samples).

Table 4-1. Results of epi-benthic tows at 5 stations sampled in Areas PHB-A, PHB-B, and PHB-C

Station	Tow time (minutes)	Knobbed Whelk	Horseshoe Crab	Blue Crab	Lady Crab	Hermit Crab	Sponge	Sand Dollar	Spider Crab	Mud Crab
A-6	4	4			1					
A-1	4	1		1		1	1			2
A-16	4							1		
A-9	4				1	1				
A-12	4	5			1					
B-3	2	5	1							
B-4	5				1					
B-7	2		1				1			
B-10	2	17					1			2
B-17	3	2								
C-2	4	2			3	1	1			
C-3	4	2								
C-4	4	6	1				1			3
C-15	4	14	1			1			12	
C-17	4	2		1	1		1			2

Within the preferred borrow area PHB-B, 17 sites were sampled. A total of 101 taxa were found, 40 were polychaete worms, 29 were arthropod crustaceans, and 19 were molluscs (mostly clams and snails). Twenty-three of the these taxa collected are epifaunal species. Seventy-six percent of all specimens collected were amphipods (Figure 4-2).

Differences in the number of taxa and specimens collected appeared to be correlated with sediment type. Sampling stations with predominantly sandy material were located to the east, while stations exhibiting a mix of sand and mud were located in the more northern and central regions of the borrow area. The most abundant taxa associated with sampling locations possessing muddy sediments appears to be the gastropod snail *Acteocina canaliculata*. Sandy stations had higher numbers of the small crustacean *Tanaissus psammophilus* and haustorid amphipods.

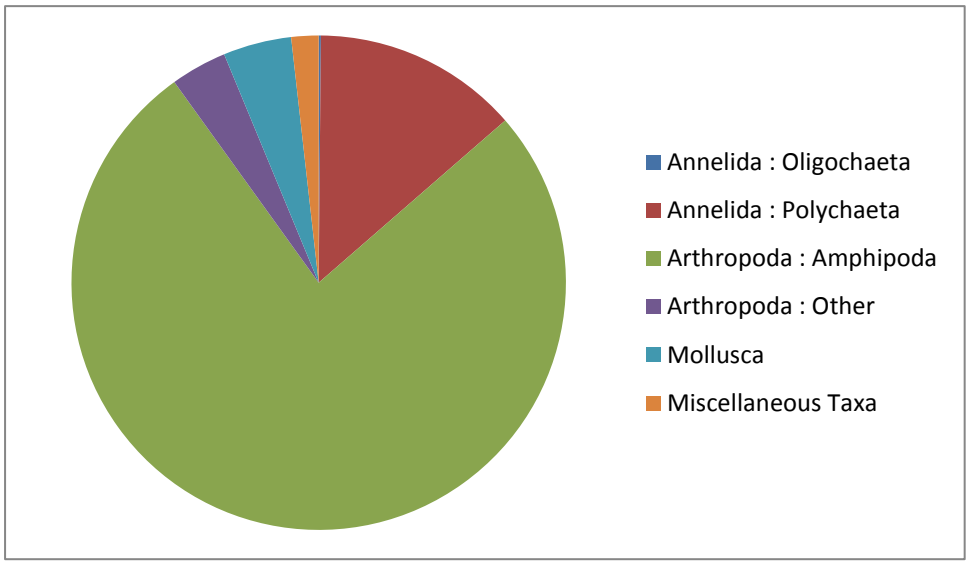


Figure 4-2: Area PHB-B- major taxonomic contribution to benthic community composition.

The taxa collected from all three borrow areas exhibited an affinity for sediment type collected at each station within the borrow area. Community patterns in terms of numbers and types of species identified from each sample were similar to each other across sites depending on similar amounts of sand and mud at the station. Most benthic studies indicate that dredging has only temporary effects on the infaunal community, and in some studies, differences in infaunal communities were attributed to seasonal variability or to hurricanes rather than to dredging (Posey and Alphin, 2002). Within months to years, and if environmental conditions permit, the initial surface-dwelling opportunistic species would be replaced by benthic species that represent a more mature community (Bonsdorff, 1983).

4.6.3 Fish

Under the No Action scenario fish would continue to be impacted by lower habitat quantity and quality through loss of wetlands, particularly for juvenile life stages that rely on saltmarshes as nursery areas. Healthy productive wetlands also provide increased diversity of prey species for fish relative to barren mudflats.

Beach placement of sand in shallow intertidal areas and dredging within the proposed borrow area have limited and short-term impacts on finfish. With the exception of some small finfish and early developmental stages that are typically found more often in tidal creeks and backwater areas, most bottom dwelling and pelagic fishes in Delaware Bay are highly mobile and should be capable of avoiding turbidity impacts of dredging and placement during operations. Although the filling of the breaches, will reduce the direct access of the pelagic fishes of the Delaware Bay to the Refuge, it is anticipated that the overall restoration of the marsh platform (through the excavation of the historic channels) will greatly increase the connectivity and access for pelagic fishes from Slaughter Canal and Creek (to the North) throughout the Refuge to Prime Hook Creek and the Broadkill River (to the South). Existing conditions, are not conducive, to non-existent, to allowing access of pelagic species that enter Unit II (through the breaches) to Slaughter Canal (to the north) and to Unit III (to the south), due to the absence of channels and impediments to movement (the existing water control structures and road-ways). Due to suspension of food particles in the water column, some finfish are attracted to the turbidity plume. Few studies have

addressed the effects of beach nourishment on surf zone fishes (Van Dolah *et al.*, 1994). The effects in the intertidal and nearshore zones may be similar, although on a smaller scale, to the effects of storms (Hackney *et al*., 1996). Even though fishes regularly occurring in the surf zone are adapted to high energy environments, rapid changes in habitat can cause mortality. Storms, and in particular, hurricanes have caused large changes in inshore fish community structure and fish kills in Florida (Robins, 1957; Breder, 1962).

The primary impact to fisheries is the disturbance of benthic and epibenthic communities. As mentioned above, the loss of benthos smothered during berm construction and removed during borrow area dredging temporarily disrupts food resources in the impact areas (Hackney *et al*., 1996). This effect is expected to be temporary, as noted above, due to the documented rapid recolonization that can occur in these highly dynamic environments. Depending on the time of year, benthos food resources can recolonize from dredged areas rather quickly (*e.g.* within a year) via larval recruitment as well as from immigration of adults from adjacent, undisturbed areas (Burlas *et al*., 2001); Posey and Alphin, 2002; Byrnes *et al*., 2003). Recovery is most rapid if dredging is completed before seasonal increases in larval abundance and adult activity in the spring and early summer (Herbich, 2000). Opportunistic benthic species are adapted to exploit suitable habitat when it becomes available post-dredging.

Many fish communities, particularly those that utilize salt marshes for feeding and nursery areas, are expected to benefit from the restoration of tidal marshes, and will be monitored during and after the project. Changes in fish communities will be monitored through seasonal surveys, and movement of species, such as white perch, American eel, and herring species, using acoustic tagging.

4.6.4 Essential Fish Habitat Assessment

EFH is defined as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity" and covers all habitat types utilized by a species throughout its life cycle. The Magnuson-Stevens Fishery Conservation and Management Act (Public Law 104-267) requires all Federal agencies to consult with NMFS on all actions, or proposed actions, permitted, funded, or undertaken by the agency, that may adversely affect EFH.

Potential impacts to EFH under the No Action scenario has been described in the previous sections in reference to surface water quality and benthic invertebrate prey species for both the intertidal zone and the proposed borrow areas. In regard to impacts due to implementation of the preferred plan, dredging within the proposed borrow area has the potential to impact EFH several ways: by direct entrainment of eggs and larvae; the creation of higher suspended sediment levels in the water column, reduce feeding success for site-feeding fish; and reduce water oxygen levels. All of these impacts are temporary in nature, during and briefly after the actual dredging period. Substrate conditions can often return to similar preconstruction conditions and the benthic community recovers through recolonization.

A review of EFH designations and the corresponding 10 feet by 10 feet squares, which encompass the project area was completed and coordinated with the NMFS (M. Magliocca, pers. comm.). The following is an evaluation of the potential effects associated with this project on EFH species:

Species/Management Unit	Scientific Name	Life stage(s) Found at Location	Potential Activities Effect
Clearnose Skate	*Raja eglanteria*	Adult	Clearnose Skate habitat for juveniles and adults is generally shallow soft bottoms or rocky, gravelly bottoms. Adults tend to move from shallow shores to deeper water in winter. Impacts may occur to larvae through entrainment. Juveniles and adults are highly mobile. Temporary disruption of benthic food prey organisms may occur within the borrow area.
Sand Tiger Shark	*Carcharias taurus*	Neonate Juvenile Adult	Neonates and early juveniles are found in shallow coastal waters and use the Delaware Bay. Adults are highly migratory and mostly congregate offshore. No adverse impact is anticipated for juveniles or adults as these stages are expected to move out of the construction area during the temporary construction period. No dredging is anticipated to occur during the warmer months when sand tigers occur in the Delaware Bay, and the dredge pipe will be floated on pontoons to avoid disrupting movements of young sand tiger sharks. Sand is pumped onto the beach above the mean high water line to minimize turbidity at the construction site.
Winter Skate	*Leucoraja ocellata*	Adult	Winter Skate habitat consists of shallow coastal water over sand or gravel and up to 80 fathoms. Juveniles and adults are highly mobile. Larvae may be impacted through entrainment. A temporary disruption to benthic food prey organism may occur.
Little Skate	*Leucoraja erinacea*	Adult	Little Skate habitat consists of shallow coastal water over sand or gravel and up to 80 fathoms. Juveniles and adults are highly mobile. Larvae may be impacted through entrainment. A temporary disruption to benthic food prey organism may occur. The species is likely to avoid the immediate impact area.
Window Pane Flounder	*Scophthalmus aquosus*	Eggs Larvae Juvenile	No adverse effect is anticipated on eggs and larvae as they are pelagic and work will be conducted on the bottom during the temporary construction period offshore. No adverse effect on juveniles and adults is anticipated in bottom habitats of the berm placement site as these life stages are anticipated to move away from the placement disturbance area during the temporary construction period. Pumping of material onto the beach will occur above the mean high water line and thereby minimize turbidity and disruption of prey species composition.
Winter Flounder	*Pseudopleuronectes americanus*	Larvae Eggs Juvenile Adult	No permanent adverse effect is anticipated on adult and juveniles because both stages can move away from the project impact area during construction. Adult winter flounder typically spawn in inlets during late fall to late winter. Eggs are demersal and epibenthic flounder larvae may burrow into the bottom and may be impacted by dredging through entrainment. Minimal adverse effect is expected on eggs and larvae within the proposed dredging and placement area. Dredged material is pumped onto the beach berm above the mean high water line. This also serves to minimize turbidity in the intertidal zone and reduce the impact to prey items.
Red Hake	*Urophycis chuss*	Adult	No adverse effect is anticipated on adults as any that may occur in the Delaware Bay during the temporary construction period are anticipated to move away from the project area.
Bluefin Tuna	*Thunnus thynnus*	Juvenile	No adverse effect is anticipated on adults as any that may occur in the Delaware Bay during the temporary construction period are anticipated to move away from the project area.

Species/Management Unit	Scientific Name	Life stage(s) Found at Location	Potential Activities Effect
Smooth Dogfish	*Mustelus canis*	ALL	Smooth dogfish is a common coastal shark species found in the Atlantic Ocean from Massachusetts to northern Argentina. They are primarily demersal sharks that inhabit continental shelves and are typically found in inshore waters down to 200m depth. Neonates and early juveniles are found in shallow coastal waters and use Delaware Bay as a nursery area. Adults are highly migratory and mostly congregate offshore. No adverse impact is anticipated for juveniles or adults as these stages are expected to move out of the construction area during the temporary construction period. No dredging is anticipated to occur during the spring and summer pupping season and the dredge pipe will be floated on pontoons to avoid disrupting movements of young sandbar sharks. Sand is pumped onto the beach above the mean high water line to minimize turbidity at the construction site.
Sandbar Shark	*Carcharhinus plumbeus*	ALL	Neonates and early juveniles are found in shallow coastal waters and use Delaware Bay as a nursery area. Adults are highly migratory and mostly congregate offshore. No adverse impact is anticipated for juveniles or adults as these stages are expected to move out of the construction area during the temporary construction period. As the lower and middle Delaware Bay have been designated as a Habitat Areas of Particular Concern (HAPC) for nursery and pupping grounds, no dredging will be anticipated to occur during the spring and summer pupping season and the dredge pipe will be floated on pontoons to avoid disrupting movements of young sandbar sharks. Sand is pumped onto the beach above the mean high water line to minimize turbidity at the construction site.
Summer Flounder	*Paralichthys dentatus*	Adult Juvenile	No adverse effect is anticipated on eggs and larvae because they are pelagic and generally collected at depths of 30 to 360 feet. No adverse effect is anticipated on juveniles and adults because they would be expected to move out of the dredging area. Impacts within the placement area are minimized due to pumping of material onto the beach above the mean high water line and reducing turbidity. Impacts to prey species in the intertidal zone will be temporary. The predominant benthic community composition consists of dominant small taxa, such as polychates and small bivalves, species with fast recruitment rates.
Black Sea Bass	*Centropristis striata*	Juvenile Adult	No adverse effect is anticipated on juveniles and adults as this species occurs primarily in offshore areas with structure and they can avoid temporary impacts to the water column and prey species during the dredging period. Larvae are generally found on structural inshore habitat such as sponge beds. No sponge beds or complex bottom habit was detected in the proposed borrow area. Black sea bass eggs are found from May through October on the Continental Shelf from southern New England to North Carolina.
Scup	*Stenotomus chrysops*	Adult Juvenile Eggs	Eggs and larvae are abundant in estuaries from May through September in waters between 55 and 73 degrees F and salinities greater than 15 ppt. No adverse impact is expected on the eggs and larvae, as dredging activates are not expected to commence until the fall. Juvenile and adults typically occur in estuaries and bays and migrate to coastal waters in summer. Older life history stages of the species would be expected to avoid the immediate dredging area during temporary construction. No impacts at the placement site are anticipated as any increase in turbidity at the placement site is minimal with pumping above the mean high water line. Prey species composition may be temporarily impacted due to dredging and placement activities.

Species/Management Unit	Scientific Name	Life stage(s) Found at Location	Potential Activities Effect
Longfin Inshore Squid	*Doryteuthis pealeii*	Adult	No adverse impacts are anticipated. Pealeii eggs occur in inshore and offshore bottom habitat where bottom water temperatures between 10°C and 23°C, salinities are between 30 and 32 ppt and depths are less than 50 meters. Conditions at the borrow site are not conducive to egg mass or "mop" anchoring, due to the shallower depths and lower salinities. Adult are not anticipated to be impacted, as longfin inshore squids are generally found over bottom depths between 6 and 200 meters, where bottom water temperatures are 8.5-14°C and salinities are 24-36.5 ppt. The borrow sites shallow depth and warmer bottom temperatures (during dredging) would not make this location ideal habitat. Juveniles and adults are expected to move away from the project area during the temporary construction period. Elevated turbidity is short-term.
Bluefish	*Pomatomus saltatrix*	Adult Juvenile	No adverse effect on eggs and larvae, as these occur in pelagic waters in deeper water than the project area and generally not collected in estuarine waters. Juveniles and adults occur in mid-Atlantic estuaries from April through October. Temporary impacts to prey items may occur in the project area. Juveniles and adults are expected to move away from the project area during the temporary construction period. Elevated turbidity is short-term.
Atlantic Butterfish	*Peprilus triacanthus*	Larvae Adult Juvenile	No adverse impacts are anticipated. All life history stages are pelagic and construction activities will take place on the bottom. Elevated turbidity effects are temporary.
Atlantic Herring	*Clupea harengus*	Adult Juvenile	No adverse effect is anticipated as adults and juveniles occur in pelagic waters and can move away from the project area during the temporary construction period. Eggs occur on bottom habitats of gravel, sand, cobble or shell fragments in depths ranging from 20 to 80 meters and a salinity range of 32-33 and are therefore not expected to be in the project area.

In conclusion, of the species identified with FMPs, and juvenile life history stages of highly migratory pelagics that may occur in the vicinity, the potential for adverse impacts to EFH is considered temporary and minimal. The egg and larval stages of winter flounder, which occur predominantly in inlets, are less likely to be impacted in the borrow area and placement vicinities. The neonate stages of several shark species are predominately located in shallower coastal waters during summer months, and should be sufficiently mobile to leave the construction area. Potential impacts are further minimized by conducting dredging operations during the cooler, nonbreeding months of the year (*i.e*. fall and winter). To protect juvenile shark species, the dredge pipe will be floated to avoid disruption of movements.

The effect on benthic organisms (including food prey items) in the borrow area is considered to be localized, temporary, and reversible as benthic studies have demonstrated recolonization following dredging operations within 13 months to 2 years. In addition, the dredging methodology is designed to minimize changes to bottom topography through the creation of ridges as the hydraulic cutterhead moves along the bottom removing sediment and creating ridges as opposed dredging a deep depression. This method also allows for quicker recruitment from the immediately adjacent ridges where the benthic community is left intact. This is in contrast to the extended time period required for recruitment of benthic organisms in deep holes that alter hydrographic characteristics of the habitat. Elevation differences or substrate type changes are also minimized with the creation of shallow ridges as opposed to

one large depression. The total impact to EFH is considered minimal due to the fact that not all of the 845-acre surface area of the borrow area is dredged. The project requires approximately 1.1 million cubic yards (mcy). PHB-B is estimated to contain over 14 mcy cubic yards of sand. With a dredging depth limit of -5 feet, PHB-B has a quantity of over 6 mcy of borrow sand available. Relative to the total quantity of similar shallow bay bottom surface habitat (grain size and depth) that is available in the lower Delaware Bay region, the impact area within the borrow area is small.

At the beach placement site (nearshore zone), the slurry of dredged material and water pumped onto the beach typically results in an increase in localized turbidity. The Atlantic States Marine Fisheries Commission (Greene, 2002) review of the biological and physical impacts of beach nourishment cites several studies on turbidity plumes and elevated suspended solids that drop off rapidly seaward of the sand placement operation. Other studies support this finding that turbidity plumes and elevated TSS levels are typically limited to a narrow area of the swash zone downcurrent of the discharge pipe (Burlas *et al*., 2001). Fish eggs and larvae are the most vulnerable to increased sediment in the water column and are subject to burial and suffocation. Juvenile fish and adults are capable of avoiding sediment plumes. Increased turbidity due to placement operations will temporarily affect fish foraging behavior and concentrations of food sources are expected to return to the nearshore zone once placement operations cease due to the dynamic nature of nearshore benthic communities (Burlas *et al*., 2001). Turbidity impacts are anticipated to be minimized by the placement of the dredge pipe above the mean high water line during pump-out and development of the raised beach berm moving along the shoreline. Most shallow water coastal species will leave the area of disturbance at the immediate placement site.

Fish seining surveys conducted at the breach, and within the Unit II, (by the USFWS) have showed that the breach and interior are not utilized by the fish species of concern (as listed in the preceding table).The breach and the marsh interior seine sampling collected 30 different species, and were dominated by common salt marsh and near shore species, such as: mummichogs, atlantic silversides, white perch, pipefish, blue spotted sunfish, black drum, yellow bullhead, and American Eel.

4.7 Wildlife

Under the No Action scenario, wildlife species would continue to incur further losses in habitat quality and quantity due to ongoing flooding. Several mammals, reptiles and amphibian, as presented in Section 3.7, inhabit the beach and wetland habitat of the refuge. All of these species are mobile and expected to leave the immediate impact area temporarily during construction. The diamondback terrapin is a common inhabitant of the Delaware Bay, utilizing marshes, tidal flats, and beaches associated with saltmarsh systems. The terrapin breeds in sandy substrate above the level of normal high tides. It is expected that all species could benefit from a beach berm and wetland restoration project as restored native habitat.

The basic premise of wetland management is to produce a diverse habitat with abundant and varied plant and animal food resources. The project goal is to restore wildlife habitat lost to tidal flooding. The conservation of birds is a primary objective (USFWS, 2008; DWAP, 2006). Beach nourishment operations should have minimal effect on birds in the area. Most birds are seasonally transient, as well as highly mobile and can avoid the construction area due to the noise. Saltmarsh restoration will serve to enhance the diverse habitats within the refuge used by birds for breeding, feeding, and resting. Saltmarsh obligate birds would expand into the restored tidal marsh for breeding and foraging. Birds that use the beach for nesting and breeding are more likely to be affected by beach nourishment activities than those species that use the area for feeding and resting during migration (USDOI/MMS, 1999). Birds may be temporarily displaced by dredges, pipelines, and other equipment along the beach, or may avoid foraging along the shore if they are aurally affected (Peterson *et al*., 2001). Sand that is placed on the beach has

the potential to crush eggs, hatchlings, and adult birds if placement occurs during the breeding season. Timing of beach placement activities will prevent these impacts. Sediment that is coarse or high in shell content can inhibit the birds' ability to extract food particles in the sand. Very fine sediment that temporarily reduces water clarity can also decrease feeding efficiency of birds in the immediate area of construction for a short period of time (Peterson *et al*., 2001). The materials proposed for placement are neither coarse nor very fine.

The beach berm and dune restoration plan will provide added protection to interior shrub and forested habitats. Widespread population declines of many migratory songbird species are among the most critical issues in avian conservation today. Numerous studies have shown the critical role that maritime shrub, maritime red cedar woodland, and maritime forested habitats play for migrating passerines, especially on the refuge and along the Mid-Atlantic and Delmarva peninsula coastal areas (Mizarhi, 2006; Clancy and McAvoy, 1997; McCann *et al.*, 1993). Conservation of these habitats and the natural resources associated with them is essential to perpetuate the migratory songbird resources of North America.

4.8 Threatened and Endangered Species

As presented in Section 3.8, several species of sea turtles and one fish species under NMFS' jurisdiction are known to migrate along the Atlantic Ocean coast, while some enter the Delaware Bay. These include the Loggerhead sea turtle (*Caretta caretta*), Kemp's ridley sea turtle (*Lepidochelys kempi*), Green sea turtle (*Chelonia mydas*), Leatherback turtle (*Dermochelys coriacea*), and Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*). Potential impacts to marine species include impingement or entrainment in the dredge, interaction with the dredge or transport vessels, elevated levels of suspended sediments that may impact foraging, migration or prey species, and noise due to project construction operations.

Sea turtles. The loggerhead is the most abundant species of sea turtle in U.S. waters. They migrate north along the east coast as water temperatures warm in the spring and move back south in fall. They typically feed on benthic invertebrates in hard bottom habitats (NMFS and USFWS, 2008). Mansfield (2006) saw a decline from the 1980s to the 2000s in loggerhead spring residency in Chesapeake Bay and attributed to significant declines in prey items such as horseshoe crabs and blue crabs. The Kemp's ridley is the least abundant of the world's sea turtle species. Suitable habitat occurs where there are available food resources (*e.g*. crabs, invertebrates), typically seagrass beds, oyster reefs, sandy and mud bottoms, and rock outcroppings (NMFS and USFWS, 2007). The Kemp's ridley utilizes Delaware Bay for foraging (Stetzar, 2002) but leave the area to migrate down the coast to the south Atlantic and Gulf of Mexico in fall. Green sea turtles are herbivorous and found in areas containing benthic algae and seagrasses. Seasonally, they are found in the mid-Atlantic but are not common (Musick and Limpus, 1997; Morreale and Standora, 1998; Morreale *et al.*, 2005). Leatherback turtles have the widest distribution of all extant sea turtles species (from as far south as the Cape of Good Hope in Africa to as far north as Alaska and Norway. Leatherbacks feed in colder waters and primarily occur in open oceanic waters and considered rare in Delaware Bay.

The proposed project is not anticipated to adversely affect sea turtle species on land as these species do not nest in the area. The furthest north leatherbacks nest is southeastern Florida; Kemp's ridleys only nest in Mexico; and loggerheads nest as far north as Virginia. Nesting in the mid-Atlantic is generally rare. In August 2011, a green turtle laid eggs in a nest at Cape Henlopen Beach, Lewes, Delaware. The 190 eggs were transported indoors to an incubation facility in October. A total of 12 eggs hatched, with eight hatchlings surviving. It is believed that had the nest not been removed from outdoors in October, fall and winter temperatures would not have been warm enough for hatchlings to survive. Potential impacts to adults would occur in the water and include loss of benthic prey items in the proposed borrow areas and injury or death from the dredge. Although the employment of on-board observers is required on hopper

dredges during times of the year when sea turtles are present, a hopper dredge will not be utilized for the project.

Atlantic sturgeon. *A. oxyrhinchus* is a long-lived species (approximately 60 years), late maturing, estuarine-dependent anadromous (Bigelow and Schroeder, 1953; Vladykov and Greeley, 1963; Dadswell, 2006; ASSRT, 2007). They can grow to over 14 feet in length and weigh up to 800 pounds (Pikitch *et al*., 2005). Spawning areas within the Delaware Estuary are not yet well defined, but believed to occur in flowing water above the salt line and below the fall line of the river (Shirey *et al*., 1999). Larvae and young juveniles are believed to remain in the estuary, particularly the upper reaches. Subadults, and adults are more salt-tolerant and travel out of the Delaware Bay at the mouth to the Atlantic Ocean (Brundage and O'Heron, 2009), typically in late summer and early fall. There is no abundance estimate for the Delaware River population of Atlantic sturgeon. Sampling in 2009 targeted young-of-the-year (YOY) and resulted in the capture of 34 YOY (Fisher, 2009) and 32 YOY in a separate study (Brundage and O'Heron in Calvo *et al*., 2010). A late fall/winter time frame has been proposed for dredging to occur when the likelihood of sturgeon present in the project area is lower. Reine *et al*. (2014) assessed impacts of dredging on Atlantic sturgeon in the James River, Virginia. To assess potential entrainment by a cutterhead suction dredge, 5 Atlantic sturgeon were tracked using both active and passive transmitters. Lateral and vertical movements of the sturgeon were examined in relation to river bathymetry, river discharge rate, dredge production rate, and vessel traffic. None of the tagged fish showed evidence of avoidance behavior, and remained in close proximity to the dredge for as long ast 21.5 hours before moving away. No strong evidence of attraction was observed either sturgeon moved past the operating dredge on several occasions. Movements appeared to be more influenced by tidal flows.

Dredging and vessel strikes are known threats to Atlantic sturgeon populations within the Delaware Estuary (Brown and Murphy, 2008). Improvement in water quality is no longer considered an impediment (Albert, 1988). NMFS is in the process of drafting a recovery plan for Atlantic sturgeon that will establish recovery goals and criteria. Currently, numerous research activities are underway, involving NMFS and other Federal, State, and academic partners, to obtain more information on the distribution, abundance and behavior of Atlantic sturgeon within the Delaware Estuary and other rivers of the Mid-Atlantic Bight.

As previously mentioned in Section 3.8, the shortnose sturgeon (*A. bevirostrum*), a federally listed endangered species, is not expected to occur within the lower Delaware Bay project vicinity.

The effects of dredging on listed sea turtle species and sturgeon varies depending on the type of dredge used. Most sea turtles and sturgeon are able to escape a dredge due to its slow speed of the advancing draghead and a smaller cutterhead dredge is recommended within the project area to minimize the risks of entrainment or impingement. Interactions with hopper dredges can cause sea turtle or sturgeon mortality through crushing as the draghead is placed on the bottom or if the sea turtle is impinged on the draghead through suction or entrainment. Procedures to minimize impacts are also employed to ensure that the draghead is properly seated on the bay bottom before starting suction, thereby reducing the risk of injury to sea turtles and sturgeon. Sturgeon are benthic feeders and are often found at or near the bottom while foraging and moving within rivers. However, information suggests that Atlantic sturgeon are up off the bottom while in offshore areas traveling in the channel and are not expected to occur in the shallower waters of the project site.

Hydraulic dredges convey sand to the placement site through a pipeline and require less transiting. Material is directly mixed with water. Sea turtles are not known to be vulnerable to entrainment by hydraulic cutterhead dredges. Because the flow field is produced by suction of the operating draghead buried in the sediment, and the proposed borrow area is located in a large open (lower bay) area, it is

likely that sturgeon can also avoid an oncoming cutterhead dredge and leave the area. Studies by Clarke (2011) performed swim tunnel tests on juvenile and subadult Atlantic sturgeon and concluded that there is a risk of entrainment only within 1 meter of the cutterhead for a 36-inch pipe diameter and suction of 4.6 m/second. The overall risk of entrainment in a wide area such as lower Delaware Bay is low. Risk is related to swimming stamina, which is positively correlated with total fish length. Entrainment of larger (*i.e*. subadult and adult) fish, which are those that can potentially be present within the project vicinity, is less likely due to their increased swimming performance and the relatively small size of the draghead opening (Hoover *et al*., 2005; Boysen and Hoover, 2009). The risk of entrainment is thought to be much higher in areas where sturgeon movements are restricted (*e.g*. in narrow rivers). Tracking studies of Atlantic sturgeon in the Delaware Estuary supports this assessment of risk, as none of the tagged sturgeon were attracted to or entrained by operating dredges (Brundage and O'Heron, 2011).

Due to the possibility of encountering munitions and explosives of concern (MEC) or unexploded ordnance (UXO) within borrow areas, screening is required on all dredges for beach nourishment projects by the Philadelphia District USACE. Beginning in 2007, dredges are outfitted with (1) a screening device placed on the dredge intake or in a pipeline section prior to reaching the dredge pump, and (2) a screen at the discharge end of the pipeline on the beach. The purpose of the screening is to prevent ordnance from being deposited on the beach by dredging. The screening device on the dredge intake prevents the passage of any material greater than 1.25 inches in diameter. The maximum allowable opening size is 1.25 inches by 6 inches. The screening device on the discharge end (on the beach) is designed to retain all items 0.75 inches in diameter and larger. Visual inspection of the screens and sand placement are performed at a minimum of once every 8 hours. The use of munitions screens further reduces the likelihood of entrainment (NMFS, 2014).

In coordination with NMFS, the Philadelphia District USACE requires turtle deflector devices on the draghead of hopper dredges used between June and November in lower Delaware Bay to reduce the risk of sea turtle entrainment. A NMFS-approved turtle monitor is required onboard hopper dredges between May 1 and November 15 to monitor, however a hopper dredge is not expected to be utilized for this project. In Delaware Bay, dredge cycles have been conducted previously during the May to November period with no observed entrainment and as many as two sea turtles have been entrained in as little as a 3-week period. Even in locations where thousands of sea turtles are known to be present (*i.e*., Chesapeake Bay) and where dredges are operating in areas with preferred sea turtle depths and forage items, the numbers of sea turtles entrained is an extremely small percentage of the likely number of sea turtles in the action area. This is likely due to the distribution of individuals throughout the action area, the relatively small area which is affected at any given moment, and the ability of sea turtles to avoid the dredge even if they are in the immediate area. Sea turtles do not occur in the action area from December through April and are not expected to be entrained during these months. Measures can be taken to minimize potential dredging impacts fish species, including the Atlantic sturgeon, by scheduling dredging during the fall and early winter months (D. Fox, pers. comm., 2010).

As presented in Section 4.3, water quality impacts are anticipated to be minor and temporary. No information is available on the effects of TSS on sea turtles, but studies on the effects of turbid waters on fish suggest that concentrations of TSS can reach thousands of milligrams per liter before an acute toxic reaction is expected (Burton, 1993). Temporary turbidity plumes from dredging may affect turtle behavior or turtle prey behavior but turtles are highly mobile and are likely to avoid areas of increased suspended solids. The risk of entrainment in a cutterhead dredge is considered to be low.

In 2012, the Philadelphia District conducted formal Section 7 consultation for the Delaware River Main Channel Deepening (DRMCD) project and subsequent maintenance of the 45-foot channel, and in particular, to evaluate impacts to the newly listed Atlantic sturgeon. NMFS issued a Biological Opinion

(BO) for this project (NMFS, 2012). This consultation also reinitiated formal Section 7 consultation for the shortnose sturgeon and four species of sea turtles (loggerhead, Kemp's ridley, green sea turtle and hawksbill), and now supersedes the previous BO (NMFS, 1996) for these species for Delaware Estuary dredging activities. NMFS (2012) provided a comprehensive review of potential impacts related to all aspects of dredging for the aforementioned species. Entrainment, turbidity, contaminants, habitat alterations, and food resource impacts were all evaluated based on the type of dredging activity (hydraulic, hopper, mechanical) and placement operations (*i.e*. both upland confined disposal and beneficial use – beach replenishment). NMFS (2012) concluded:

> "*After reviewing the best available information on the status of endangered and threatened species under NMFS jurisdiction, the environmental baseline for the action area, the effects of the action and the cumulative effects, it is NMFS' biological opinion that the proposed action may adversely affect, but is not likely to jeopardize the continued existence of the shortnose sturgeon, any DPS of Atlantic sturgeon, Kemp's ridley and loggerhead sea turtles, and is not likely to adversely affect green or leatherback sea turtles. Because no critical habitat is designated in the action area, none will be affected by the proposed action.*"

NMFS (2012) provided reasonable and prudent measures (RPMs) to minimize impacts and monitor for incidental take, which include the implementation of state of the art turtle deflectors on hopper dredge dragarms, endangered species monitors on hopper dredges or disposal locations, notification procedures, and post dredge substrate monitoring. Although the preferred proposed borrow area (PHB-B), and the proposed placement location of dredged material for the Prime Hook recovery project were not considered by NMFS in their BO for the Main Channel Deepening project (*i.e.* placement operations of Reach E material onto Broadkill Beach), the actions of the two projects are very similar in both operation and locality. Construction of the proposed project will abide by the RPMs outlined for activities within the Federal channel in NMFS (2012) as well as any additional RPMs, as established by NMFS that may result from further consultation with NMFS pertaining specifically to the proposed project.

Some marine mammals may be classified as threatened or endangered species, but all fall under the jurisdiction of the Marine Mammal Protection Act. The marine mammal species that are commonly encountered in the Delaware Estuary or traveling past the mouth of the Delaware Bay within the Atlantic Ocean are bottlenose dolphin (*Tursiops truncatus*), harbor porpoise (*Phocoena phocoena*), humpback whale (*Megatera novaeangliae*), harbor seal (*Phoca vitulina concolor*), and gray seal (*Halichooerus grypus*). Species not commonly sighted but could possibly utilize the lower estuary are pygmy sperm whale (*Kogia breviceps*), long-finned pilot whale (*Globicephala melaena*), fin whale (*Balaenoptera physalus*), northern right whale (*Eubalaena glacialis*), harp seal (*Cystophora cristata*), and ringed seal (*Poca hispida*).

Marine mammals would be expected to avoid dredging operations within the Delaware Bay. Section 7 of the ESA of 1973, as amended, requires federal agencies to consult with the NMFS to ensure that the action carried out is not likely to jeopardize the continued existence of any endangered species or threatened species or adversely modify or destroy designated critical habitat. Coordination with NMFS's Protected Resources Division (PRD) has been initiated for this project and will be completed prior to the construction phase. The impact to listed species should be minimal and operations are not expected to impact migratory pathways. There may be a temporary reduction in prey species in the area. To the extent practical, dredging operations will be scheduled at times of the year when most marine species are unlikely to occur in the area and utilize a cutterhead suction dredge rather than a hopper dredge.

The piping plover (*Charadrius melodus*) is a federally listed endangered small pale shorebird on sandy beaches along the Atlantic Ocean and Gulf coasts. The species has been observed by State and refuge

staff in the proposed project area only rarely, during migration, but has not been observed exhibiting nesting behavior. The proposed work will not be conducted during the spring migration period. Under the No Action scenario, very little, if any suitable piping plover habitat currently exists. It is possible that upon completion of construction of the nourished beach, suitable habitat may be established and piping plovers may utilize the area for foraging and nesting in the future.

The *rufa* subspecies of the red knot (*Calidris canutus rufa*) has recently been listed as a federally threatened species. The red knot is a migratory shorebird that is typically found on Delaware Bay beaches during spring and fall migrations, including the beaches in the vicinity of Prime Hook NWR. For migratory shorebirds, the current beach fronting the refuge is suboptimal habitat for feeding due to the prevalence of exposed mudflat and eroded exposed peat and little sandy beach. Red knots are not anticipated to occur frequently in the project area because the current conditions do not offer quality foraging areas. However, the actions proposed for the project area are most likely to positively affect this species by creating preferred feeding and resting habitat. Construction of the project will cause disturbance to the beach but will not occur while red knots are in the area. Construction will be completed prior to any disturbance restrictions that will be determined through the accusation of all necessary State and Federal permitting and through the ongoing discussions with the State of Delaware Heritage Program.

Although the bald eagle (*Haliaeetus leucocephalus*) and the peregrine falcon (*Falco* peregrines) have been recently removed from the Federal endangered species list, these raptors do occur in the project area. The bald eagle is still protected under the Bald and Golden Eagle Protection Act and both birds are protected under the Migratory Bird Treaty Act.

The Delmarva fox squirrel, a species listed as endangered a half century ago, has recovered across many parts of its historic range, and the Service has removed it from the endangered species list. No impacts to the Delmarva fox squirrel are anticipated as the species would not be present in the project area where dredged material will be placed. Delmarva fox squirrels reside in the interior forests of the refuge where no project impacts will occur. Currently, saltwater intrusion is reducing the amount of forested acreage within the refuge. The preferred plan to renourish the beach and develop adequate wetland elevations will serve to reduce saltwater intrusion into the refuge's interior forested areas.

The State-endangered resident species on the refuge include the pied-billed grebe (*Podilymbus podiceps*), northern harrier (*Circus cyaneus*), Cooper's hawk (*Accipiter cooperii*), black rail (*Laterallus jamaicensis*), and Forster's tern (*Sterna forsteri*). State-endangered species that have attempted to breed on the refuge include the American oystercatcher (*Haematopus palliates*), least tern (*Sternula antillarum*), and common tern (*Sterna hirundo*). The actions proposed for the project area are expected to positively affect these species by creating preferred feeding and nesting habitat. Rare sightings of other State-endangered species using the refuge in the spring, fall, or winter include the brown creeper (*Certhia Americana*), black-crowned night heron (*Nycticorax nycticorax*), yellow-crowned night heron (*Nyctanassa violacea*), hooded warbler (*Setophaga citrine*), red-headed woodpecker (*Melanerpes erythrocephalus*), and sedge wren (*Cistothorus platensis*).

The DNHP rare, endangered, and threatened flora species identified in Section 3.8 (McAvoy *et al*., 2007) do not occur within the direct footprint area of the proposed project and occur in primarily freshwater and interior upland areas of the refuge. Under the No Action scenario, these plants will continue to be vulnerable to saltwater intrustion. However, these rare plant communities will likely continue to persist and possibly expand under the proposed restoration plan. The establishment of channels and saltwater flow into Management Unit III should concentrate higher saline waters within the easternmost portion of the unit while reserving the western portion for fresh water areas through the major influence of Prime Hook Creek (A. Larsen, USFWS pers. comm.)

The majority of faunal species that are likely to occur within the immediate construction area are sufficiently mobile to vacate the area during the construction period. Invertebrates and small vertebrate species will be directly impacted through burial during dredging placement operations and channel excavation. Although foraging capacity within the immediate construction area will be temporarily impacted, the project is expected to improve the habitat in a relatively short period of time for recolonization as the beach and saltmarsh vegetation is restored, thereby reducing the potential for future flooding and storm-related impacts and allow shrub and forested habitats to re-establish.

4.9 Climate and the Influence of Sea Level Rise on the Physical Environment

The U.S. Climate Change Science Program (USCCSP, 2009) determined coastal sensitivity to sea level change and climate change scenarios with a focus on the mid-Atlantic region. Although the long-term tide gauge data record during the past century shows an average global SLR of about 1 to 2 mm per year, within the Delaware Estuary, the sea level trend over the past 100 years has been 2.8 mm per year at Philadelphia, Pennsylvania and 3.2 mm per year at Lewes, Delaware (Haidvogel *et al*., in prep.). The average Delaware marsh accretion rate has been 3 mm per year for the last 100 years (Nikitina *et al*., 2000). More recently (1992 to 2009), the sea level trend in Delaware Bay has increased to nearly 5 mm/year. Land subsidence within the refuge is likely a contributing factor in these higher rates. Most erosion along the Delaware Bay shoreline is caused by waves generated by local winds, especially during storms.

Climate change adaptation is critical to the future management of the refuge. Disruption of the natural coastal processes within the beach barrier and adjacent saltmarsh complex by impounding renders the area more susceptible to flooding. Erosion rates of the refuge shoreline along Unit II were quantified by the DNREC Coastal Programs. The rate of shoreline retreat between 1937 and 1954 (prior to impounding) was 50 feet at Fowler Beach, but eroded an additional 50 feet in only 5 years between 2007 and 2012. Shoreline position has been monitored carefully every spring and fall since 2011. Between spring 2011 and spring 2014, the shoreline retreated about 27 feet in most areas, which represents a continued erosion rate of about 10 feet per year. However, the total shoreline retreat in many areas of the project site over that time was about 30 to 60 feet (Psuty *et al*., 2010).

The natural creation of overwashes and landward migration of the shoreline are beneficial to saltmarshes (Ashton *et al*., 2007). Saltmarsh vegetation builds elevation by trapping sediment during flood events, building up below ground biomass and accumulating organic matter (Cahoon *al et*., 2009). The accretion of marsh elevation helps to keep pace with SLR and serves to help anchor the marsh/beach complex. Analysis of sediment cores by the DNREC Coastal Programs, in cooperation with the University of Delaware, found that Unit I has been accreting over approximately the last 50 years at a rate nearly equal to or greater than the current local SLR (3.2 mm per year). However, the average rate of accretion for the same period in Unit II (with an impoundment) was 1.7 mm per year, half of the sea level rate.

Global Positioning System (GPS) surveys documented in some areas less than an inch in elevation between wetland vegetated areas and open water areas. Because the elevation of the impounded areas is barely above sea level, they are highly susceptible to salt water inundation during coastal storm events. Freshwater impoundment management on the refuge is not sustainable long-term given the proximity to the Delaware Bay in the presence of SLR. The impoundments have existed for a relatively short period of time in the refuge's history and were conceived to meet waterfowl management objectives, and established, in part, using existing roads which had not been formally engineered as long-term water level management dike infrastructure. Freshwater marshes within the impoundments were predominantly colonized with annual vegetation that differs from salt marsh vegetation. Annual freshwater wetland

plants contribute to above-ground biomass, whereas tidal saltmarsh perennial vegetation contributes persistent below-ground organic matter and greater vertical accretion of sediments (Cahoon *et al*., 2009).

The proposed plan will re-establish the beach berm and dune system and supplement substrate elevations along the back barrier marsh platform for the establishment of a *Spartina*-dominated saltmarsh. Wetlands are the second line of defense from tidal inundation behind the beach and dunes and serve to absorb floodwaters. Reintroduction of historically aligned tidal channels within the wetlands will serve to continually feed the wetlands a sediment and nutrient source for plant growth and accretion, and provide a well oxygenated, accessible habitat to aquatic organisms and nutritional source for plant, all necessary elements to keep pace with SLR.

It is difficult to predict the impact of climate change on aquatic endangered species (*i.e.* sea turtles and sturgeon as there is uncertainty in the rate and timing of climate change as well as the effects it may have on these species. Sea turtles may be affected by increasing sand temperatures at nesting beaches which may result in increased female to male sex ratio among hatchlings. SLR could result in a reduction in available nesting beach habitat and increase risk of nest inundation, and changes in abundance and distribution of forage species. Changes in water temperature could lead to a northward shift in the sea turtle range, however, the anticipated change in sea temperatures within the next 50 years is not expected to be greater than 1.5 to 2.0 and not deemed significant enough to contribute towards shifts in range or distribution of sea turtles (NMFS, 2014) or warm enough for successful egg rearing. Nesting north of Virginia is relatively rare and would not occur in the project area.

Rising sea level may result in moving the salt wedge upstream, and potentially reducing available freshwater habitat for spawning, larvae, and younger juvenile Atlantic sturgeon. Increased rainfall, as predicted by some climate models, may increase runoff and scour, thereby exacerbating poor water quality conditions but possibly also counter-affect a northern encroachment of the salt wedge. Warmer water temperatures can impact dissolved oxygen levels. Atlantic sturgeon prefer water temperatures up to approximately 28 degrees Celsius. Increased droughts (or increased withdrawals for human use) and low flow conditions are additional potential impacts unrelated to the proposed project that can impact all Atlantic sturgeon life stages by reducing suitable habitat and reduce water quality conditions.

Rising sea levels are anticipated to continue to affect coastal fish and wildlife habitats, including those utilized by waterfowl, wading birds, and shorebirds. Successful conservation strategies must address physical changes resulting from foreseeable future conditions within the refuge. The Service will continue to work with its partners, such as the Delaware DNREC, Ducks Unlimited, the USGS, the NOAA and others to research and monitor the current and likely physical and biological impacts of climate change, and to assess species and habitat vulnerabilities. This information will be used to formulate guidelines or thresholds to mitigate habitat losses and assist ongoing ecosystem adaptation to the refuge's changing environment.

4.10 Cultural Resources

4.10.1 Nearshore Sand Borrow Areas

In conjunction with the planned harvesting of sand in Delaware Bay for the Prime Hook NWR Dune Breach Repair Project, an Underwater Archaeological Remote Sensing Investigation was conducted to determine the presence or absence of possible submerged cultural resources within three potential borrow areas in Delaware Bay, Sussex County, Delaware. The three borrow areas were designated as PHB-A (351 acres), PHB-B (880 acres), and PHB-C (599 acres). Comprehensive magnetic and acoustic and remote sensing surveys and target analysis were conducted across the potential borrow areas to identify

targets suggestive of submerged cultural resources that might be impacted by the sand harvesting activities (Cox, 2014).

Comprehensive remote sensing survey of the borrow area using magnetic and acoustic instrumentation resulted in the identification of no potentially significant remote sensing targets. No additional underwater archaeological investigations are recommended in the three offshore borrow areas.

A determination of *No Effect* on historic properties eligible for or listed on the NRHP will be coordinated with the State Historic Preservation Office (SHPO).

4.10.2 Dune and Beach Berm Construction

The proposed dune and beach fill constriction will have no effect on historic properties eligible for or listed on the NRHP. A determination of *No Effect* on historic properties eligible for or listed on the NRHP will be coordinated with the SHPO.

4.10.3 Wetland Restoration

The 30-mile of channel to be dredged is an existing system. No additional channels will be created within the APE. Furthermore, although cultural resources have been documented within Units II and III, the proposed thin layer side cast of dredged material will only serve to cover and protect those sites. A determination of *No Adverse Effect* on historic properties eligible for or listed on the NRHP will be coordinated with the SHPO.

4.10.4 Access Points and Staging Areas

Although no subsurface cultural resource investigation has been conducted in the three proposed staging areas, protective measures will be taken to avoid impact to any resources that may be intact below the plow zone. With the protective measures in place, a determination of *No Effect* to historic properties eligible for or listed on the NRHP will be coordinated with the SHPO.

4.11 Socioeconomic Environment

This section evaluates the degree to which the preferred plan may affect the local economy, social structures, or quality of life of the local communities in and around the refuge. Restoring the biological integrity of habitats within the refuge will likely have consequences on the socioeconomic environment. However, it is difficult to accurately quantify monetary value for ecosystem services accrued by the natural habitats restored. Ecosystem services are the benefits to humans such as erosion control, water and air quality enhancement, carbon sequestration, storm protection, nutrient cycling, and habitat provision for wildlife and recreation. Saltwater, salt marshes, freshwater wetlands, forests, and ponds all provide different levels of environmental services.

Under the No Action scenario, the continued saltwater intrusion into the refuge interior and erosion of the coast will result in increased damages from storms. The adverse impact to area agriculture, if the marshes are not restored, is an increase of saltwater intrusion, erosion of the coast, and increased damages from storms. Crops typically have a low tolerance to salinity so if salinity intrusion is allowed to continue under the No Action plan, interior field productivity and quality would decrease. Mature stands of trees will continue to die due to saltwater intrusion. Wildlife-dependent recreational resources, such as hunting, fishing, wildlife observation, and general enjoyment of natural spaces would be adversely affected with the continued loss of wetlands and habitat diversity. As land loss through erosion or

subsidence continues, the wildlife abundance in the refuge would decrease. Lower quality fish spawning and nursery habitat may translate to a decline in sport fishing success on and around the refuge. Conversion of emergent marsh to large unvegetated open water and mudflat would result in a diminished capacity of the area to support fish and wildlife populations. Failure to restore and maintain coastal wetlands will likely result in increases in damages from storm surges. Local long-term beneficial impacts to the socioeconomic environment would be realized from the placement of dredged material into the marsh and barrier beach. Restoration of the marshes to historic salt marsh conditions would once again provide natural storm buffering, limit storm surge heights, and provide protection for the interior wetlands and uplands (USACE, 2010).

The proposed plan will not only restore several thousand acres of salt marsh and freshwater marshes, but will also protect nearly 900 acres of forested habitats from further degradation due to salt water intrusion. The demise of the riparian forests along the western boundaries of the Management Units II and III is attributed to the salt water that was driven into these areas by winds and storm surges. The proposed restoration of the dune/marsh complex will reduce the elevation of storm tides; reduce the effects of the winds by restoring frictional resistance associated with marsh vegetation thereby reducing the negative effects of salt water intrusion into the extant forest communities. The protected forest communities along with the 4,000 acres of re-established natural marshes will provide better storm surge and flood protection, carbon sequestration, fish and wildlife habitat, and enhance air and water quality. The National Fish and Wildlife Foundation (NFWF) released a report (Southwick Assoc., 2011) titled "The Economics Associated with Outdoor Recreation, Natural Resources Conservation, and Historic Preservation in the United States." The value reported for ecosystem services was $10,608 per acre per year for wetlands and $1,014 per acre per year for forests. In Cecil County, Maryland, Weber (2007) calculated the following values per acre per year: $12,033 for upland forest, $43,685 to $52,765 for freshwater wetlands, and $28,146 for tidal marsh. Kaufman (2011) discussed ecosystem service values in the Delaware River Basin as $13,621 per acre per year for freshwater wetlands, $7,235 for salt marsh, $1,978 for upland forest, and $1,946 for open water.

Combining the wetland and upland habitats, if they are in a healthy condition within the refuge, the total value of Prime Hook's ecosystem services can range from $60 million to $110 million per year (Industrial Economics, 2011). The implication of insect pollinators and non-chemical mosquito control management are seldom taken into consideration in economic analyses but their benefits are important as well.

4.11.1 Environmental Justice

Appropriate measures will be taken to ensure that any resulting projects are consistent with local, regional, State, and Federal regulations. Implementation of the preferred plan is not anticipated to result in any new significant or negative human health or safety impacts. The proposed project will not have a disproportionately high adverse effect on minority or low income populations and is in compliance with Executive Order 12898. The project would generally have beneficial social and economic effects and would generally affect all persons equally.

4.12 Air Quality

Air quality is generally good in the refuge area. Emissions of criteria pollutants, greenhouse gases, and other hazardous air pollutants would result from operation of the dredge pumps and coupled pump-out equipment, dredge propulsion engines, and tugs, barges, and support vessels used in the placement and relocation of mooring buoys. In addition, air emissions would result from bulldozers, trucks, and other heavy equipment used in the construction of the berm, dune and wetlands. Carbon monoxide and particulate emissions at the project site, during construction, may be considered offensive; but are

generally not considered far-reaching. Exhaust from the construction equipment will have an effect on the immediate air quality around the construction operation but should not impact areas away from the construction area. These emissions will subside upon cessation of operation of heavy equipment.

4.12.1 General Conformity Review and Emissions Inventory

The 1990 Clean Air Act Amendments include the provision of Federal Conformity, which is a regulation that ensures that Federal actions conform to a nonattainment area's State Implementation Plan (SIP) thus not adversely impacting the area's progress toward attaining the NAAQS. Prime Hook NWR is located in Sussex County, Delaware, which is part of the Seaford, Delaware nonattainment area. The area is classified as marginal nonattainment for ozone (oxides of nitrogen [NOx] and volatile organic carbons [VOCs]). For Federal actions within a marginal nonattainment area, the EPA has set limits of 100 tons NOx and 50 tons VOCs per year.

There are two types of Federal Conformity: Transportation Conformity (TC) and General Conformity (GC). TC does not apply to the proposed construction projects because they are not funded with Federal Highway Administration money and they do not impact the on-road transportation system. However, GC is applicable to the USACE beachfill and the Service's tidal channel excavation projects. Therefore, the total direct and indirect emissions associated with each project construction must be compared to the GC trigger levels stated above. Criteria pollutant emissions are estimated from power requirements, duration of operations, and emission factors for the various equipment types (Appendix C).

One construction project for the Prime Hook NWR restoration and recovery project to be completed by the USACE, Philadelphia District is the creation of a beach berm and dune with a back barrier wetland platform utilizing beachfill sand dredged from the nearshore borrow area. The total estimated emissions that would result from construction of the berm/dune and back barrier wetland platform project by the USACE are 85.95 tons of NOx and 2.34 tons of VOCs. These emissions are below the GC trigger levels of 100 tons per year of NOx and 50 tons per year of VOCs for a marginal nonattainment area. GC under the Clean Air Act, Section 176 has been evaluated for this portion of the project according to the requirements of 40 CFR 93, Subpart B. The requirements of this rule are not applicable to this project because the total emissions from the project are below the conformity threshold values established at 40 CFR 93.153 (b) for ozone (NOx and VOCs) in a Marginal Nonattainment Area (100 tons of NOx and 50 tons of VOCs per year). The project is not considered regionally significant under 40 CFR 93.153 (i).

The other portion of the Prime Hook NWR restoration and recovery project will be completed by the Service and entails excavation of shallow tidal circulation channels within historical footprints of natural tidal channels that previously existed in the interior area of the former freshwater impoundments of Management Units II and III. As with the USACE construction project, the Service's excavation project of interior wetland tidal circulation channels will result in emissions that are below the GC trigger levels for a marginal nonattainment area. The total estimated emissions that would result from wetland tidal channel excavation are 32.42 tons of NOx and 0.71 tons of VOCs. The project is not considered regionally significant under 40 CFR 93.153(i).

4.13 Hazardous, Toxic, and Radioactive Waste

Borrow area and beach nourishment activities are not expected to result in the identification and/or disturbance of Hazardous, Toxic, and Radioactive Waste (HTRW), as it has been found that coarse-grained material like sand in a high-energy area is unlikely to be contaminated with HTRW (USACE, 1994). Although the potential is low, small caliber UXO may be encountered in the borrow areas during dredging operations. As a safety precaution, and mentioned in Section 4.8, the USACE requires that a

screen be placed over the drag head to effectively prevent any of the UXO from entering the hopper and before being subsequently placed on the beach. In the event that ordnance is encountered in the borrow area, the screening and/or magnetometer sweeping will all but eliminate the possibility of any ordnance remaining on the new beach after construction.

The contractor would be responsible for proper storage and disposal of any hazardous material such as oils and fuels used during the dredging and beach nourishment operations. The EPA and U.S. Coast Guard regulations require the treatment of waste (*e.g.*, sewage, gray water) from dredge plants and tender/service vessels and prohibit the disposal of debris into the marine environment. The dredge contractor will be required to implement a marine pollution control plan to minimize any direct impacts to water quality from construction activity.

4.14 Noise

Project-related noise at the placement site during construction will consist of the sound of dredged material passing through the pipe and discharging in a plume of water. Earth-moving equipment, such as bulldozers, will shape the newly deposited dredged material and produce engine noise in the nearby vicinity. Smaller side-casting (*i.e.* thin-layer spraying) dredges will be used inside the flooded wetland area for tidal channel excavation. Utilizing heavy earth-moving machinery fitted with approved muffling apparatus reduces noise and vibration impacts.

At the proposed borrow area, hydraulic suction dredging involves raising loosened material to the sea surface by way of a pipe and centrifugal pump along with large quantities of water. Suction dredgers produce a combination of sounds from relatively continuous sources including engine and propeller noise from the operating vessel and pumps and the sound of the drag head moving across the substrate. The smaller suction dredges (*e.g*. 8 to12 inch), proposed for use within the interior of the refuge for thin layer side-casting dredging of the tidal channels, produce lower noise levels than larger suction dredges. Based upon data collected by Reine *et al*. (in prep.), sediment removal and the transition from transit to pump-out would be expected to produce the highest sound levels from larger suction dredges at an estimated source level (SL) of 172 decibels (dB) at 3 feet. The two quietest activities would be seawater pump-out (flushing pipes) and transiting (unloaded) to the borrow site, with expected SLs of approximately 159 and 163 dB at 3 feet, respectively. Based upon attenuation rates observed by Reine *et al*. (in prep.), it would be expected that at distances approximately 1.6 to 1.9 miles from the source, underwater sounds generated by the dredges would attenuate to background levels. However, similar to in-air sounds, wind (and corresponding sea-state) would play a role in dictating the distance to which project-related underwater sounds would be above ambient levels and potentially audible to nearby receptors. Underwater noise levels exceeding 160 dB could harass marine mammals.

Robinson *et al*. (2011) carried out an extensive study of the noise generated by a number of trailing suction hopper dredgers during marine aggregate extraction. Source levels at frequencies below 500 hertz (Hz) were generally in line with those expected for a cargo ship travelling at modest speed. The dredging process is interspersed with quieter periods when the dragheads are raised to allow the dredge to change positions. Clarke *et al*. (2002) evaluated sound levels produced by a hopper dredge during its “fill” cycle working in a sandy substrate. They found that most of the sound energy produced fell within the 70 to 1,000 Hz range, with peak pressure levels in the 120 to 140 dB range at 40 meters from the dredge. These data correlate well with a study conducted in the United Kingdom which found trailing suction hopper dredge sounds to be predominately in the low frequency range (below 500 Hz), with peak spectral levels at approximately 122 dB at a range of 56 meters (DEFRA, 2003). It is unlikely that a hopper dredge will be used for this project. Hopper dredges require doubling handling, whereas a hydraulic cutter suction dredge pumps the material directly to the placement site. Due to the shallow water depths within the

project area, a smaller hydraulic dredge will likely be required, which typically produces lower noise levels than larger hydraulic dredges.

Underwater sounds generated by hydraulic pipeline dredging operations are generally considered to be of low frequencies (< 1000 Hz) (Clarke *et al*., 2002); much lower than spectral noise levels produced by hopper dredges (Reine *et al*., 2012); and limited to less than 100 meters from the source. In a review by Southall *et.al.* (2007) several studies showed altered behavior or avoidance by dolphins to increased sound related to increased boat traffic in the immediate vicinity. Clarke *et al.* (2004) found that cutterhead dredging operations are relatively quiet compared to other sounds in aquatic environments, whereas hopper dredges produce somewhat more intense sounds. Thomsen *et al.* (2009) conducted a field study to better understand if and how dredge-related noise is likely to disturb marine fauna. This study found that the low-frequency dredge noise would potentially affect low- and mid-frequency cetaceans, such as bottlenose dolphins. Noise in the marine environment has also been responsible for displacement from critical feeding and breeding grounds in several other marine mammal species (Weilgart, 2007). Noise has also been documented to influence fish behavior (Thomsen *et al*., 2009). Fish detect and respond to sound utilizing cues to hunt for prey, avoid predators, and for social interaction (LFR, 2004). It is likely that at close distances to the dredge vessel, the noise may produce a behavioral response in mobile marine species, with individuals moving away from the disturbance, thereby reducing the risk of physical or physiological damage. Accordingly, any resulting effects would be negligible. It is unlikely that underwater sound from conventional dredging operations can cause physical injury to fish species (Reine *et al*., 2012).

4.15 Cumulative Impacts

Cumulative Impacts, as defined in Council on Environmental Quality (CEQ) regulations (40 CFR Sec. 1508.7), are the "impacts on the environment which result from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time."

Cumulative impacts were discussed in chapter 5 the CCP/EIS (2012) for the alternative plans evaluated, including the Service's preferred Alternative B. The cumulative impacts discussion included the actions of other agencies and organizations that influenced the same environment by evaluating how the refuge activities interact with other actions occurring adjacent to the refuge as well as over the State and regional spatial and temporal frame of reference.

The Department Secretarial Order 3226 states that "there is a consensus in the international community that global climate change is occurring and that it should be addressed in governmental decision-making". The order ensures that climate change impacts are taken into account in the Department's planning, particularly with respect to long-term planning documents such as the CCP. As previously mentioned in Section 4.9, projecting impacts to fish and wildlife resulting from climate change is complex due to the number of factors. Potential stressors on wildlife include changing precipitation and temperature patterns, their rate of change, the introduction of exotic species, loss of habitat through inundation, other developed land uses, disease introduction and other factors. Impacts of the proposed projects are temporary for the duration of the construction periods and would not likely contribute to new significant cumulative impacts to the area. The Service's proposed tidal channel excavation project will most likely be completed or near completion when the proposed USACE beachfill project begins. Conversely, the proposed project would serve to reduce direct impacts of SLR on the refuge by providing a protective beach barrier and dune, temper interior water circulation, and provide adequate elevations for the re-establishment of natural vegetation.

Cumulative adverse impacts of past coastal erosion control projects typically focused on the effect these projects had on the marine borrow areas: (1) the benthic resource community, and (2) the creation of hypoxic conditions by dredging deep holes. Impacts to the nourishment sites themselves are temporary displacement of benthic resources in the short-term and positive impacts to the beach ecosystem in the long-term (enhanced storm protection and increased habitat). Since the current proposed project is designed to minimize adverse environmental effects of all types, the project should not culminate in adverse cumulative impacts on ecological resources, and should result in an overall improvement of the coastal environment. Research studies suggest that the potential impact area from proposed and existing beach nourishment actions is small relative to the area of available similar habitat in both the vicinity and on a bay-wide basis (Byrnes *et al*,. 2003). Also, for some species, such as migratory shorebirds and horseshoe crabs that utilize the shoreline, beach projects have the potential to improve habitats by replacing beach material lost to erosion. Lastly, all impacted areas are expected to recover invertebrate inhabitants, which will continue to be available as food resources.

The cumulative impacts on EFH are not considered significant. Like the benthic environment, the impacts to EFH are temporary in nature and do not result in a permanent loss in EFH. The borrow site proposed for this project does not contain prominent shoal habitat features, wrecks and reefs, or any known hard bottom features that could be permanently lost due to the impacts from dredging. Some minor and temporary impacts would result in a loss of food source in the affected area due to dredging and placement events, however, over longer-term periods, similar and typically more severe impacts often result from major storms.

Projects of a restorative nature using beachfill are becoming increasingly common in coastal areas of high development as they become more susceptible to erosive forces. Numerous beach nourishment projects have been studied along the Atlantic Ocean coast of New Jersey and Delaware since the 1960s by local, State, and Federal interests. Depending on site-specific circumstances, such as the methods utilized to alleviate coastal erosion and ensuing storm damages and the existing ecological and socioeconomic conditions, it is difficult to gauge the net cumulative effects of these actions. The scientific literature generally supports beachfill projects over structural alternatives, if properly planned, are short-term, and have minor ecological effects.

Activities conducted within the refuge that were determined in the CCP/EIS (2012) to contribute negligibly, but incrementally, to cumulative impact stressors regionally are the prescribed burning program (*i.e.* for invasive vegetation control) and use of vehicles and equipment. These measure are not included as part of the proposed project but may be utilized in the future if required through adaptive management. Alternative measures to reduce these impacts are discussed in detail in the CCP/EIS (2012).

Other projects occurring in the Delaware Estuary include construction of the DRMCD project by the USACE, Philadelphia District (USACE, 1997; 2011). To date, portions of Reaches A, AA, B, C, and D have been deepened to -45 feet. All of the completed dredging within these Reaches was accomplished by the pumping of the dredged material into upland confined disposal facilities (CDFs). The lower portion of Reach E (Brandywine Range) is scheduled to start construction in the fall of 2014. Approximately 1.6 mcy of sand dredged from the channel will be beneficially used as beach fill for the eroding beach at Broadkill Beach, just south of the refuge. Other planned projects in the lower Delaware Bay include two ecosystem restoration projects at Cape May Villas and Reeds Beach. These small beach communities are located along the New Jersey side of the lower Delaware Bay, and their purpose is to restore horseshoe crab spawning habitat and migratory shorebird resting and feeding habitat. Currently, there are no Federal funds to construct these areas. These beach nourishment projects make use of nearby

offshore sand borrow areas in the Delaware Bay to supply the sand to restore the beach habitats. The State of Delaware has conducted beachfill operations on its shorelines, including the bayshore. Since 1995, DNREC has placed sand either through hydraulic pipeline dredging or by truck haul.

A sediment supply is essential within the bay region for saltmarshes to build vertically by accumulating both organic matter (peat) from autochthonous production as well as trapped inorganic sediments washing in from other areas. Sediment supply is essential for coastal wetlands to remain resilient during storms and to keep pace with SLR. The legacy of dikes, impoundments, and tidal flow restrictions within the Delaware Estuary has left many former fringing marshes with lower elevations due to an insufficient tidal sediment subsidy over time. As these dikes and tidal restrictions become breached, the former tidal marshes typically are unable to reestablish marsh vegetation and quickly convert to mud flat or shallow open water. In order to maintain their ecological viability, tidal wetlands therefore depend on the opportunity to exchange water and sediments with the adjacent waterways, and these waterways need to carry a suitable sediment load. A sediment deficit not only adversely affects fringing wetlands but developed bayshore residential communities as well. The State of Delaware released a report describing the maintenance needs of the developed beach communities along the bayshore, in order to counteract the effects of coastal erosion (DNREC and PBS&J, 2010). The report indicated that there is a long term and perpetual need for roughly 94,000 cubic yards of sand per year to counteract the effects of erosion at seven bayfront communities in the southern part of the State. Potential sources of this material include hydraulic dredging from offshore borrow areas or navigation channel dredging, or trucking from inland sources.

In 2014, the State of Delaware received $6.9 million from the Department's Hurricane Sandy Coastal Resiliency appropriations. The funds were awarded to Delaware through a competitive grants program administered by the NFWF to assess and improve resiliency of the Delaware Bay coastline. These efforts will complement the proposed restoration plans for Prime Hook NWR by providing increased protection to neighboring lands, infrastructure, and communities along the bayshore from future coastal storms and SLR. The restoration goals are to utilize natural assets such as sand dunes and salt marshes to benefit both the fish and wildlife species that depend on them for habitat, and to protect bayshore communities threatened by coastal storms, flooding, and SLR. The areas targeted for restoration projects include from Mispillion Harbor (near the town of Slaughter Beach) to Milford Neck Conservation Area and from the Mahon River (near the town of Little Creek) to the St. Jones River. Additionally, coastal impoundments and beach habitat at the Ted Harvey Conservation Area and the Little Creek Wildlife Area will be restored.

The DelDOT received a Federal Highway Administration grant to construct a 60 to 70 foot raised causeway at the east end of Prime Hook Road to reduce flooding over that low-lying segment of the road. The bridge will allow for tidal water exchange and drainage underneath as a necessary element to the proposed re-establishment of the historical network of channels within the refuge. The channels from both the Mispillion/Slaughter Canal and Broadkill Rivers that travel through the refuge will provide stable tidal flows and reduce storm surge elevations that have impacted the bayfront. Hydrologic connection of the proposed channels within Management Unit III to Unit II, currently separated by Prime Hook Road, will be completed once the DELDOT raised bridge is constructed.

4.16 Relationship Between Short-term Uses of the Environment and the Enhancement of Long-term Productivity

The Service's primary aim for the refuge is to maintain or enhance the long-term productivity and sustainability of natural resources within the refuge, in the State of Delaware, and in the Delmarva Coastal Plain ecosystem for resident and migratory birds, fish, and wildlife species. Habitat restoration

efforts may entail short-term negative impacts for a greater, more long-term outcome of productivity. Cyclic management activities that will be conducted at the refuge as part of the proposed restoration plan, such as prescribed burning of invasive plants, have short-term impacts to the area. Short-term impacts of beach nourishment dredging and placement operations, and channel excavation will occur. Such impacts covered in the preceding sections of this report include a temporary reduction in benthic invertebrate fauna and a short-term evacuation of mobile bird and fish species during construction.

The intended long-term benefits of an ecosystem restoration project typically offset the short-term impacts. Long-term management actions by Service staff are proposed in conjunction with the construction project to restore a natural tidal flow to the system to allow for *Spartina* recolonization. A more natural coastal vegetative community in turn supports the links between nutrient cycling, carbon sequestering, and other ecological processes important to ecosystem function. Wetlands, both coastal and interior, influence the transport of nutrients in conjunction with hydrological flow patterns. Vegetative structural diversity in the form of dead wood, leaf litter, senesced wetland vegetation, and detritus all contribute to terrestrial and aquatic invertebrate resources and nutrient recycling, which in turn enhances the long-term benefits of the refuge's resources for wildlife and people.

4.17 Unavoidable Adverse Effects

Unavoidable adverse effects are those that could cause harm to the environment and species that occur there. The unavoidable adverse impact of the No-Action alternative of beach nourishment would be continued erosion of the existing beach and adjacent wetlands, and continued loss of habitat. The unavoidable adverse impact of berm and dune restoration and breach repair, as well as to the nearshore borrow area is a temporary decrease in benthic fauna. All of the alternatives proposed for restoration involve minor, localized and unavoidable adverse effects as described in the preceding sections.

Some habitat types, such as the former freshwater impoundments in Units II and III have been impacted as a result of saltwater inundation. The proposed project will result in less acreage of freshwater habitat in the easternmost portions of the refuge, however, in areas where conversion from freshwater to salt marsh has already occurred due to flooding, these areas had been originally historic tidal salt marsh habitat. The project is designed to retain freshwater fed habitat within the interior of Unit III. Unavoidable impacts that result from actual construction can be mitigated by the use of practices and precautions that safeguard water quality, such as siltation curtains, and avoid sensitive or rare habitats or time of year limitations. The adverse effects generally are short-term and more than offset by the long-term gains in habitat quality, fish and wildlife productivity, plant productivity, increased recreational opportunities, and higher coastal storm resiliency.

No long-term adverse impacts are anticipated to result from implementation of the proposed plan. Furthermore, as the refuge land is managed by full-time staff, any unforeseeable impacts would be mitigated with best management practices.

4.18 Potential Irreversible and Irretrievable Commitments of Resources

Irreversible commitments of resources are those that cannot be regained. For example, an action that contributes to a species' extinction. By comparison, irretrievable commitments of resources are those that can be reversed, given sufficient time and resources, but represent a loss in production for a time. One example of an irretrievable commitment is allowing the natural succession of a grassland area, habitat for Henslow sparrow, adjacent to a saltmarsh revert gradually to maritime scrub shrub habitat, rather than the refuge staff continue to maintain that grassland habitat with mowing. The natural conversion of some acreage of former freshwater impoundment to tidal saltmarsh is an irretrievable commitment, although, as

mentioned previously, these areas had been originally historic tidal salt marsh habitat. Interior freshwater areas fed by Prime Hook Creek will continue to be vegetated and inhabited by freshwater plant and wildlife species.

Berm and dune restoration involves the utilization of fossil fuels, which are irreversible and irretrievable. Impacts to the benthic community would not be irreversible, as benthic communities would reestablish with cessation of placement activities.

5.0 Environmental Regulations and Coordination

The Prime Hook NWR Ecosystem Restoration project has adhered to the following environmental quality protection statutes and other environmental review requirements.

Archaeological Resources Protection Act of 1979, as amended	Full
Clean Air Act, as amended	Full
Clean Water Act of 1977	pending
Coastal Zone Management Act of 1972, as amended	pending
Endangered Species Act of 1973, as amended	pending
Estuary Protection Act	Full
Emergency Wetlands Resource Act of 1986	Full
Federal Water Project Recreation Act, as amended	N/A
Magnuson-Stevenson Act, Essential Fish Habitat	Full
Marine Mammal Protection Act	Full
Marine Protection, Research and Sanctuaries Act	Full
Migratory Bird Conservation Act	Full
National Historic Preservation Act of 1966	pending
National Environmental Policy Act, as amended	Full
National Wildlife Refuge Improvement Act of 1997	Full
Refuge Recreation Act	Full
Rivers and Harbors Act	pending
Coastal Barrier Resources Act	Full
EO 11988, Floodplain Management	Full
EO 11990, Protection of Wetlands	Full
EO 12114, Environmental Effects of Major Federal Actions	Full
EO 12898, Environmental Justice	Full
EO 13186, Protection of Migratory Birds	Full

All necessary permits and approvals are issued by the regulatory agencies and will be obtained prior to construction. Although the Coastal Barrier Resources Act specifies that designated areas are ineligible for most new Federal expenditures and financial assistance, clear exemptions are made for management, protection, and enhancement of fish and wildlife resources, including stabilization projects for fish and wildlife habitats. The appropriation for this project is the Hurricane Sandy Disaster Relief Supplemental Appropriation Act of 2013, Public Law 113-2. Stafford Act – New Jersey Area: Emergency Declaration, Emergency Management (EM) -3354, Major Disaster Declaration, Disaster, Disaster Recovery (DR) -4086.

Subsequent to release of the CCP/EIS in December 2012, the Service continued to meet with natural resources agencies and participate in public coordination meetings to update interested parties in the project's development. The Service sought and obtained the USACE and the NMFS as cooperating agencies. In December 2014, the Service met with DNREC officials with review and regulatory roles to provide an update on the restoration plan. To establish a monitoring program to document pre-, during, and post-construction conditions, the Service is working collaboratively with DNREC's Coastal Program and the University of Delaware. The Service has kept the public informed through both regularly-scheduled briefing meetings, presentations, and postings to the Service's Prime Hook NWRs webpage (http://www.fws.gov/refuge/Prime_Hook/what_we_do/marshrestoration.html), and will continue to do so throughout the project's construction (Appendix B).

6.0 LITERATURE CITED

Adamowicz, S.C. and C.T. Roman. 2002. Initial ecosystem response of salt marshes to ditch plugging and pool creation: experiments at Rachel Carson National Wildlife Refuge (Maine). USGS Patuxent Wildlife Research Center, Narragansett, RI.

Albert, R.C. 1988. The historical context of water quality management for the Delaware Estuary. Estuaries, Vol. 11. No. 2 pg 99-107.

Amos, W. 1966. The life of the seashore. New York: McGraw-Hill, Inc.

Anchor Environmental, CA, L.P. 2003. Literature review of effects of resuspended sediments due to dredging operations. Prepared for the Los Angeles Contaminated Sediments Task Force, Los Angeles, CA.

Anderson, M.G., J.A.M. Smith, and B.D. Wilson. 2010. Benthic habitats of the Delaware Bay.

Armbruster, C.K. 2000. Ecological review of new cut dune/marsh restoration. Coastal Wetlands Planning, Protection and Restoration Act (CWPPRA) Priority Project List 9 (State No. TE-37, Fed. No. TE-11a). Database/Analysis Section, Coastal Restoration Division, Louisiana Dept. of Nat. Resources.

Ashton, A.D., J.P. Donnelly, and R.L. Evans. 2007. A discussion of the potential impacts of climate change on the shorelines of the northeastern USA. Woods Hole Oceanographic Institution MS#22, 360 Woods Hole Road, Woods Hole, MA.

ASSRT (Atlantic Sturgeon Status Review Team). 2007. Status review of Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*). National Marine Fisheries Service. 23 February 2007. 188 pp.

Atkins Global, 2009. Management plan for the Delaware Bay beaches. Tampa, FL. Prepared for the Delaware Department of Natural Resources and Environmental Control.

Atkins Global, 2014a. Hydrodynamic modeling of Prime Hook National Wildlife Refuge, U.S. Fish and Wildlife Service, January 24, 2014; 102 pages.

Atkins Global, 2014b. Post-storm survey and breach analysis for Prime Hook. Task Order #2, Atkins Memorandum May 16, 2013; 29 pages.

Bain, M.B. 1997. Atlantic and shortnose sturgeons of the Hudson River: common and divergent life history attributes. Environmental Biology of Fishes 48:347-358.

Bigelow, H.B. and W.C. Schroeder. 1953. Sea Sturgeon. In: Fishes of the Gulf of Maine. Fishery Bulletin 74. Fishery Bulletin of the Fish and Wildlife Service, vol. 53.

Boesch, D.F., and R. Rosenberg. 1981. Response to stress in marine benthic communities. In 'Stress Effects on Natural Ecosystems'. (Eds G W. Barrett and R. Rosenberg.) Ch. 13, pp. 179-200. Wiley: New York.

Bonsdorff, E. 1983. Recovery potential of macrozoobenthos from dredging in shallow brackish waters. Presented at Proceedings 17th European Marine Biology Symposium, Oceanol. Acta, 27 September-1 October 1982.

Borque, B. 1979. A summary and analysis of cultural resource information concerning the Continental Shelf from the Bay of Fundy to Cape Hatteras. Vol. III – Shipping. Peabody Museum of Archaeology and Ethnology, Cambridge.

Botton, M.L., R.E. Loveland, and T.R. Jacobsen. 1988. Beach erosion and geochemical factors—influence on spawning success of horseshoe crabs (*Limulus polyphemus*) in Delaware Bay: Marine Biology, v. 99, p. 325–332.

Botton, M.L. and R.E. Loveland. 1987. Orientation of the horseshoe crab, *Limulus polyphemus*, on a sandy beach. Biol. Bull. (Woods Hole) 173:289-298.

Boysen, K. A. and J.J. Hoover. 2009. Swimming performance of juvenile white sturgeon (*Acipenser transmontanus*): training and the probability of entrainment due to dredging. Journal of Applied Ichthyology, 25:54–59.

Breder, C.M., 1962. Effects of a Hurricane on the Small Fishes of a Shallow Bay. Copeia 1962(2):459- 462.

Brenner, O.T. and L.J. Moore. 2013. The complex influences of back barrier deposition, substrate slope and underlying stratigraphy in barrier island response to sea level rise: insights from the Virginia Barrier Islands, Mid-Atlantic Bight, USA. Geomorphology.

Brooks, R.A., C.N. Purdy, S.S. Bell and K.J. Sulak. 2006. The benthic community of the eastern U.S. continental shelf: a literature synopsis of benthic faunal resources. Continental Shelf Research. 26(2006):804-818

Brown, J.R. and D.C. Miller. 2011. Persistence and distribution of temperate intertidal worm reefs in Delaware Bay: a comparison of biological and phsycial factors.

Brown, J.J. and G.W. Murphy. 2010. Atlantic sturgeon vessel strike mortalities in the Delaware River. Fisheries 3 5(2):7 2-83.

Brundage, H.M. and R.E. Meadows. 1982. The Atlantic sturgeon in the Delaware River estuary. Fisheries Bulletin 80:337-343.

Brundage, H.M. and J.C. O'Herron. 2009. Investigations of juvenile shortnose and Atlantic sturgeons in the lower tidal Delaware River. Bull. N.J. Acad. Sci. 54(2), pp 1-8.

Brundage and O'Heron in Calvo, L., H.M. Brundage, D. Haidvogel, D. Kreeger, R. Thomas, J.C. O'Heron, and E.N. Powell. 2010. Effects of flow dynamics, salinity, and water quality on the Atlantic sturgeon, the shortnose sturgeon and the eastern oyster in the oligohaline zone of the Delawsare Estuary. Final Report Project Year 2008-2009 for the U.S. Army Corps of Engineers, Philadelphia District. Seaboard Fisheries Institute.

Brundage, H.M., and J.C. O'Herron. 2011. Acoustic telemetry studies of the distribution and movement of juvenile sturgeons in the Delaware River and Estuary in 2010. Chapter 1 *in*: E. Bochenek et al. Effects of flow dynamics, salinity, and water quality on the eastern oyster, the Atlantic sturgeon, and the shortnose sturgeon in the oligohaline zone of the Delaware Estuary. Report submitted to the United States Army Corps of Engineers. Seaboard Fisheries Institute. Penns Grove, NJ.

Burlas, M, G.L. Ray, D.G. Clarke. 2001. The New York district's biological monitoring program for the Atlantic coast of New Jersey, Asbury Park to Manasquan Section beach erosion control project. Final Report. U.S. Army Engineer District, New York, and the U.S. Army Engineer Research and Development Center, Waterways Experiment Station, Vicksburg, MS.

Burton, W.H., H.M. Brundage, and J.C. O'Herron. 2005. Delaware River adult and juvenile sturgeon survey-winter *2005*. Prepared for the U.S. Army Corps of Engineers, Philadelphia District. Versar, Inc., Columbia, MD 36 pp.

Burton, W. 1993. Effects of bucket dredging on water quality in the Delaware River and the potential for effects on fisheries resources. Prepared for the Delaware Basin Fish and Wildlife Management Cooperative. Trenton, NUJ. 32 pp.

Byrnes, M.R., R.M. Hammer, B.A. Vittor, S.W. Kelley, D.B. Snyder, J.M. Cote, J.S. Ramsey, T.D. Thibaut, N.W. Phillips, and J.D. Wood. 2003. Collection of environmental data within sand resource areas offshore North Carolina and the environmental implications of sand removal for coastal and beach restoration: Volume I: Main Text, Volume II: Appendices: U.S. Department of Interior Minerals Management Service. OCS Report MMS 2000-056.

Cahoon, L.B., K.M. Hardy, and D.M. Allen. Exploring relationships between river discharge and coastal ocean phytoplankton biomass. Validated in EcoEdNet, Nov. 9, 2009. http://esa.org/ecoed/index.php?P=FullRecord&ResourceId=84

Cahoon, D.R. and G.R. Guntenspergen. 2010. Climate change, sea level rise, and coastal wetlands. National Wetlands Newsletter, Vol. 32, (1):8-12.

Clarke, D., C. Dickerson, and K. Reine K. 2002. Characterization of underwater sounds produced by dredges dredging. ASCE, Orlando, Florida, USA, p 64-64.

Clarke, D. 2011. Sturgeon protection. Presented to the Dredged Material Assessment and Management Seminar 24-26 May, 2011 Jacksonville, FL.

Clark, K.E. and Niles L.J. 2001. Northern Atlantic Regional Shorebird Plan. Version 1.0. New Jersery Division of Fish and Wildlife. Woodbine, NJ.

Caudill, J. and E. Henderson. 2005. Banking on nature 2004: the economic benefits to local communities of national wildlife refuge visitation. U.S. Department of the Interior, Fish and Wildlife Service, Division of Economics, Washington DC. Pp 345-349.

Chipley, R.M., G.H. Fenwick, J.J. Parr, and D.N. Pashley. 2003. The American bird conservancy guide to the 500 most important bird areas in the United States. American Bird Conservancy, New York.

Church, J.A. and N.J. White. 2006. A 20th century acceleration in global sea level rise. Geophysical Research Letters, Vol. 33, Issue 1.

Churchill, E.P. 1921. Life history of the blue crab. Bull. U.S Bureau of Fisheries for 1917-1918. 36:91-128.

Clancy, K. and W. McAvoy. 1997. The biota of Delaware's barrier beaches and dunes of the Delaware Bay. Task No. 95-3. Final Report submitted to the Delaware Coastal Management Program, Division of Soil and Water, DNREC, Dover, DE.

Clausen, C. 1976. The magnetometer and underwater archaeology: magnetic delineation of individual shipwreck sites, a control technique. International Journal of Nautical Archaeology and Underwater Exploration. Vol. 5. No. 2.

Conner, W.G. and J.L. Simon, 1979. The effects of oyster shell dredging on an estuarine benthic community. Estuarine and Coastal Marine Science 9:749-578.

Coxe, R. 2013. Historical analysis and map of vegetation communities, land covers, and habitats of Prime Hook National Wildlife Refuge, Sussex County, Delaware: Cedar Creek, Slaughter Creek, Prime Hook Creek and Broadkill River Watersheds. Delaware Natural Heritage and Endangered Species Program, Delaware Division of Fish and Wildlife, Wildlife Section, Smyrna, Delaware, 545 pp.

Cox, L. 2014. Phase I underwater archaeological project, Prime Hook National Wildlife Refuge, dune breach repair project, lower Delaware Bay, Sussex County, Delaware. Report for U.S. Fish and Wildlife Service.

Curtis, L. 1973. Aspects of the life cycle of *Sabellaria vulgaris* Verrill (Polychaeta: Sabellaridae) in Delaware Bay. Ph.D. Dissertation, University of Delaware, Newark, DE.

Curtis, L. 1975. Distribution of *Sabellaria vulgaris* Verrill (Polychaeta: Sabellaridae) on a sandflat in Delaware Bay. *Chesapeake Science* 16:14–19.

Custer, J.F. 1984. Delaware prehistoric archaeology, an ecological approach. University of Delaware Press. Newark, DE.

Custer, J.F. 1989. Prehistoric cultures of the Delmarva Peninsula: an archaeological study. University of Delaware Press, Newark.

Custer, J.F. and G.L. Galasso. 1983. A prehistoric archaeological survey of the St. Jones and Murderkill drainages, Kent County, Delaware. Bulletin of the Archaeological Society of Delaware; No. 14 (NS).

Dadswell, M. 2006. A review of the status of Atlantic sturgeon in Canada, with comparisons to populations in the United States and Europe. Fisheries 31:218-229.

DEFRA (Department for Environment, Food, and Rural Affairs) 2003. Preliminary investigation of the sensitivity of fish to sound generated by aggregate dredging and marine construction. Project: AE0914 Final Report, London, United Kingdom.

deLange, W.P. and R.M. Carter, 2014. Sea level change. Living with uncertainty. The Global Warming Policy Foundation. GWPF Rpt 15.

Delaware Department of Natural Resources and Environmental Control (DNREC). 2008. Mosquito Control Spray Policy. Division of Fish and Wildlife, Mosquito Control Section. Dover, DE.

Delaware Department of Natural Resources and Environmental Control (DNREC). 2010a. Delaware residents' opinions on climate change and sea level rise: Discussion of survey results and messaging implications. Dover, Delaware. 20 pp. Available at: *http://www.responsivemanagement.com/download/reports/DE_SLR_WhitePaper.pdf*

Delaware Department of Natural Resources and Environmental Control (DNREC). 2010. Delaware Fish Consumption Advisory, Dover, DE.

Delaware Department of Natural Resources and Environmental Control (DNREC) and PB&J, 2010. Management Plan for the Delaware Bay Beaches, Final Report.

Delaware River Basin Commission. 2012. Delaware River and Bay Water Quality Assessment.

Delaware Wildlife Action Plan (DEWAP). 2006. Submitted by Allen, O., B. Barkus, and K. Bennett, Delaware Natural Heritage and Endangered Species Progream, Delaware Division of Fish and Wildlife, Delaware Department of Natural Resources and Environmental Control.

Dolan, R. 1972. Barrier dune system along the Outer Banks of North Carolina: a reappraisal.

Dubois, S., C. Retière, and F. Olivier. 2002. Biodiversity associated with *Sabellaria alveolata* (Polychaeta: Sabellariidae) reefs: effects of human disturbances. Journal of the Marine Biological Association (United Kingdom) 82(05):817–826.

Epifanio, C.B. 1995. Transport of blue crab (*Callinectes sapidus*) larvae in the waters off Mid-Atlantic states. Bull. Mar. Sci. 57:713-725.

Fisher, M. 2009. DNREC, Atlantic sturgeon progress report, State Wildlife Grant, Project T-4-1.

Gahagan & Bryant Associates, Inc. 2014. Delaware Bay sand investigation geotechnical report. Contract #NAT12003-SWM-ENGR prepared for Delaware Department of Natural Resources and Environmental Control. 598 pp.

Godfrey, P.J., 1976. Barrier beaches of the east coast. Oceanus, V 19, n. 5, p. 27-40.

Goldsmith, V. 1985. Coastal dunes. Chapter 5 in Davis, R.A. (Ed.) Coastal Sedimentary Environments. Springer-Verlag. New York. 716 pp.

Gore, R., L. Scotto, and L. Becker. 1978. Community composition, stability, and trophic partitioning in decapod crustaceans inhabiting some subtropical sabellariid worm reefs. *Bulletin of Marine Science* 28:221–248.

Greene, K. 2002. Beach Nourishment: A Review of the Biological and Physical Impacts. Atlantic States Marine Fisheries Commission (ASMFC) Habitat Management Series #7. 179 pp.

Hackney, C.T., M.H. Posey, S.W. Ross, and A.R. Norris. 1996. A Review and Synthesis of Data on Surf Zone Fishes and Invertebrates in the South Atlantic Bight, and the Potential Impacts from Beach Nourishment. Prepared for the Wilmington District, USACE. 111 pgs.

Haidvogel, D., Z. Wang, D. Bushek, E. Powell. In prep. Potential impacts on circulation, water properties, and the eastern oyster from future climate change in Delaware Bay.

Haley, N., J. Boreman, and M. Bain. 1996. Juvenile sturgeon habitat use in the Hudson River. Section VIII *in* J.R. Waldman, W.C. Nieder, and E.A. Blair (eds.) Final Report to the Tibor T. Polgar Fellowship Program, 1995. Hudson River Foundation, New York.

Hatin, D., Lachance, S., D. Fournier. 2007. Effect of dredged sediment deposition on use by Atlantic sturgeon and lake sturgeon at an open-water disposal site in the St. Lawrence estuarine transition zone. American Fisheries Society Symposium 56:235-255.

Hauser, O.A. 2002. Tubeworm nodule reefs of Delaware Bay.

Helser, T.E. and D. Kahn, 2001. Stock Assessment of Delaware Bay Blue Crab (*Callinectes sapidus*) for 2001. Department of Natural Resources and Environmental Control, Dover, Delaware.

Herbich, J.B. 2000. Handbook of dredging engineering, 2nd Edition. McGraw Hill.

Hoover, J.J., K.J. Killgore, D.G. Clarke, H.Smith, A. Turnage, and J. Beard. 2005. Paddlefish and sturgeon entrainment by dredges: swimming performance as an indicator of risk. DOER Technical Notes Collection (ERDC-TN-DOER-E22), U.S. Army Engineer Research and Development Center, Vicksburg, MS.

Industrial Economics, 2011. Economic valuation of wetland ecosystem services in Delaware. Prepared for the Division of Water Resources, Delaware Department of Natural Resources and Environmental Control.

Jackson, N.L., and K.F. Nordstrom. 1993. Depth of activation of sediment by plunging breakers on a steep sand beach. *Marine Geology* 115(1–2):143–151.

Jivoff, P.R. and K.W. Able. 2003. Evaluating Salt Marsh Restoration in Delaware Bay: the Response of Blue Crabs, *Callinectes sapidus*, at Former Salt Hay Farms.

Johnston Jr., S.A. 1981. Estuarine dredge and fill activities: a review of impacts. Environmental Management 5(5): 427-440.

Kaufman, G.J. 2011. Socioeconomic value of the Delaware River basin in Delaware, New Jersey, New York, and Pennsylvania. University of Delaware, Newark, DE. 88 pp.

Kraft, J.C., E.A. Allen, D.F. Belknap, C.J. John, and E.M. Maurmeyer. 1976. Geologic processes and the geology of Delaware's coastal zone, a report to the State of Delaware, Executive Department, Planning Office, Dover, DE. Published as "Delaware's Changing Shoreline" Technical Report No. 1, Delaware Coastal Management Program.

Kearney, M.S., A.S. Rogers, J.P.G. Townshend, and E. Rizzo. 2002. Landsat imagery shows decline of coastal marshes in Chesapeake and Delaware Bays. Eos, Transactions of the American Geophysical Union 83(16): 173.

Kennish, M.J. 2001. Coastal salt marsh systems in the U.S.: a review of anthropogenic impacts. Journal of Coastal Research, 17(3):731-748.

Knutson, P.L. (1988). Role of coastal wetlands in energy dissipation and shore protection. In Ecology of Wetlands, edited by D.D. Hook. Timber Press, Portland, OR: 161-174.

Knutson, P.L., R.A. Brochu, W.N. Seelig, and M. Inskeep. 1982. Wave dampening in Spartina alterniflora marshes. Wetlands 2:87–104.

Kraft, J.C. and C.J. John. 1976b. The geological structure of the shorelines of Delaware. College of Marine Studies, University of Delaware, Newark, DE. 107 pp.

Kraft, J.C. and C.J. John. 1976. Introduction to the Geological Structure of the Shorelines of Delaware. Delaware Sea Grant Technical Report DEL-SG 14-76.

Lazzari, M.A., J.C. O'Herron, and R.W. Hastings. 1986. Occurrence of subadult Atlantic sturgeon, *Acipenser oxyrinchus*, in the upper tidal Delaware River. Estuaries 9(4B):356-361.

Leatherman, S.P. 1979. Migraion of Assateague Island, Maryland, by inlet and overwash processes. Geology, Vol. 7, 1979b, pp. 104-107.

Levine Fricke Recon (LFR). 2004. Framework for assessment of potential effects of dredging on sensitive fish species in San Francisco Bay for the U.S. Army Corps of Engineers, San Francisco District, CA. 105 pp.

Lynch, Austin E. 1994. *Macroinfaunal Recolonization of Folly Beach, South Carolina, After Beach Nourishment*. Masters Thesis, University of Charleston, SC.

Mansfield, K.L. 2006. Sources of mortality, movements, and behavior of sea turtles in Virginia. Chapter 5. Sea turtle population estimates in Virginia. pp.193-240. Ph.D. dissertation. School of Marine Science, College of William and Mary.

Marshall, S., 2004. Archaeological, historical, and geomorphological study of Prime Hook National Wildlife Refuge, Sussex County, Delaware. Report for the U.S. Fish and Wildlife Service.

Maurer, D., R. Keck, J.C. Tinsman, and W.A. Leathem, 1981a. Vertical migration and mortality of benthos in dredged material. I. Mollusca-Mar. Environmental Research 4:299-319.

Maurer, D., R. Keck, J.C. Tinsman, and W.A. Leathem, 1981b. Vertical migration and mortality of benthos in dredged material. *II*. Crustacea-Mar. Environmental Research 5:301-317.

Maurer, D., R. Keck, J.C. Tinsman, and W.A. Leathem, 1982. Vertical migration and mortality of benthos in dredged material. *III*. Crustacea-Mar. Environmental Research 6:49-68.

Maurmeyer, E.M. 1978. Geomorphology and evolution of transgressive estuarine washover barriers along the western shore of Delaware Bay. Ph.D. Dissertation, University of Delaware, Newark, DE

McAvoy, W.A., R.B. Coxe, C.M. Heckscher. 2007. Prime Hook National Wildlife Refuge final report on vegetation community surveys: 2005-2006 and botanical and zoological surveys: 2004-2005. Natural Heritage and Endangered Species Program, Delaware Division of Fish and Wildlife, DNREC, Smyrna, Delaware.

McBride, R.A. and M.R. Byrnes. 1997. Regional variations in shore response along barrier island systems of the Mississippi River delta plain: historical change and future prediction. J. of Coastal Research. 13(3):628-655.

McCall, P.L. 1977. Community patterns and adaptive strategies of the infaunal benthos of Long Island Sound. J. Mar. Res. 35:221-265.

McCann, J.M., S.E. Mabey, L.J. Niles, C. Bartlett, and P. Kerlinger. 1993. A regional study of coastal migratory stopover habitat for neotropical migrant songbirds: land management implications. Transactions of the North American Wildlife and Natural Resources Conference 58:398-407.

McHugh, J.L. 1981. Marine fisheries of Delaware. Fish. Bull. 79:575-599.

Mizrahi, D.S. 2006. Oases along the flyway: preserving critical stopover habitat for migrating songbirds on the Delmarva Peninsula, Final Report to the U.S. Fish and Wildlife Service. Delaware Bay Coastal Project Office, Smyrna, DE.

Moore, L., J.H. List, S.J. Williams, K. Patsch. 2010. Barriers on the brink? The complex intertwined roles of geologic framework sediment availability, and sea-level rise in island evolution. Pp 272-285 in Wang, P. J. Rosati, and T. Roberts (Eds): Proceedings of the Coastal Sediments 2011. Vol. 1. World Scientific Publishing, NJ.

Morris, J.T, P.V. Sundareshwar, C.T. Nietch, B. Kjerfve.D.R. 2002. Responses of coastal wetlands to rising sea level. Ecology, 83(10):2869-2877.

National Marine Fisheries Service. 2011. Endangered Species Act Biological Opinion for the U.S. Army Corps of Engineers, Philadelphia District for the Delaware River Federal Navigation Main Channel Deepening Project.

National Oceanic and Atmospheric Administration (NOAA). 2011. Coastal Service Center – Beach nourishment: a guide for local government officials. http://www.csc.noaa.beachnourishment/html/geo/shorelin/htm.

Najjar, R.G., Pyke, C.R., Adams, M.B., Breitburg, D., Hershner, C., Kemp, M., Howarth, R., Mulholland, M., Paolisso, M., Secor, D., Sellner, K., Wardrop, D., Wood, R., 2010. Potential climate change impacts on the Chesapeake Bay. Estuarine, Coastal and Shelf Science 86, 1-20.

Neiring, W.A. and R.S. Warren. 1980. Vegetation patterns and process in New England salt marshes. Bioscience 30:301-307.

Nelson, D.A. and D. Dickerson. 1988. Hardness of nourished and natural sea turtle nesting beaches on the east coast of Florida. USACE Waterways Experiment Station.

Nikitina, D.L., J.E. Pizzuto, R.A. Schwimmer, and K.W. Ramsey, 2000. An updated Holocene sea-level curve for the Delaware coast. Marine Geology, 171, 7-20.

NMFS (National Marine Fisheries Service) and USFWS (U.S. Fish and Wildlife Service). 2007. Green sea turtle (*Chelonia mydas*) 5 year review: summary and evaluation. Silver Spring, Maryland: National Marine Fisheries Service. 102 pp.

NMFS (National Marine Fisheries Service) and USFWS (U.S. Fish and Wildlife Service). 2008. Recovery plan for the Northwest Atlantic population of the loggerhead turtle (*Caretta caretta*), Second revision. Washington, DC.: National Marine Fisheries Service. 325 pp.

NMFS (National Marine Fisheries Service) 2014. Endangered Species Act Biological Opinion, Use of sand borrow areas for beach nourishment and hurricane protection offshore Delaware and New Jersey. Prepared for the U.S. Army Corps of Engineers (Philadelphia District) and the Bureau of Ocean Energy Management. NER-2014-10904.

NRC (National Research Council) 1995. Beach nourishment and protection. Washington, DC. National Academy Press. 334 pp.

Oden, W.E., T.J. Smith, J.K. Hoover, and C.C. McIvor, 1984. The ecology of tidal freshwater marshes of the United States east coast: a community profile. U.S. Fish and Wildlife Service Office of Biological Services. Washington, DC. FWS/OBS-8317.

Oliver, J.S., P.N. Slattery, L..W. Hulberg and J.N. Nybakken. 1977. Patterns of succession in benthic infaunal communities following dredging and dredged material disposal in Monterey Bay. Technical Report D-77-27. U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Parr, T., E. Diener, and S. Lacy, 1978. Effects of beach replenishment on the nearshore sand fauna at Imperial Beach, California. MR 78-4. U.S. Army Corps of Engineers Coastal Engineering Research Center.

Partnership for the Delaware Estuary, 1996. The scientific characterization of the Delaware Estuary by C.C. Sutton, J.C. O'Herron, and R.T. Zappalorti. DELEP Report Number 96-02.

Peterson, C.H., D.H.M. Hickerson, and G.G. Johnson. 2000. Short-term consequences of nourishment and bulldozing on the dominant large invertebrates of a sandy beach. J. Coastal Res. 16(2):368-378.

Peterson, C.H., W. Laney, T.Rice. 2001. Biological impacts of beach nourishment. Workshop on the Science of Beach Replenishment. May 7-8, 2011. Pine Knoll Shores, NC.

Pikitch, E.K., P. Doukakis, L. Lauck, P. Chakrabarty, and D.L. Erickson. 2005. Status, trends and management of sturgeon and paddlefish fisheries. Fish and Fisheries 6:233–265.

Polis, D. and S. Kupferman. 1973. Physical Oceanography, Delaware Bay Report Series. Delaware Bay Report Series, Vol. 4, University of Delaware: 1–143.

Posey, M., and T. Alphin. 2002. Resilience and stability in an offshore benthic community: responses to sediment borrow activities and hurricane disturbance: Journal of Coastal Research 18:685-697.

Psuty N.P., A. Spahn, S. Grogan, J. Greenberg, R.T. Fullmer, and B. Kempf. 2014. Shoreline change along Prime Hook National Wildlife Refuge: Annual Monitoring Report, 2011-2014. US Fish and Wildlife Service, Hadley, MA

Psuty, N.P., M. Duffy, J.F. Pace, D.E. Skidds, and T.M. Silveria. 2010. Northeast coastal and barrier geomorphological monitoring: part I –ocean shoreline position. Natural Resources Report NPS/NCBN/NRR -2010/185. National Park Service, Fort Collins, CO.

Reilly, F.J. Jr. and V. Bellis, 1983. The ecological impact of beach nourishment with dredged materials on the intertidal zone at Bogue Banks, North Carolina. U.S. Army Corps of Engineers Coastal Engineering Research Center.

Reine, K.J., D. Clarke, M. Balzaik, S. O'Haire, C. Dickerson, C. Frederickson, G. Garman, C. Hager, A. Spells, and C. Turner. 2014. Assessing impacts of navigation dredging on Atlantic sturgeon (*Acipenser oxyrinchus*). ERDC/EL TR-14-12.

Reine, K.J., D. Clarke, and C. Dickerson. 2012. Characterization of underwater sounds produced by a hydraulic cutterhead dredge fracturing limestone rock. ERDC TN-DOER-E34.

Rich, T.D., C.J. Beardmore, H. Berlanga, P.J. Blancher, M.S.W. Bradstreet, G.S. Butcher, D.W. Demarest, E.H. Dunn, W.C. Hunter, E.E. Iñigo-Elias, J.A. Kennedy, A.M. Martell, A.O. Panjabi, D.N. Pashley, K.V. Rosenberg, C.M. Rustay, J.S. Wendt, T.C. Will. 2004. Partners in Flight North American Landbird Conservation Plan. Cornell Lab of Ornithology. Ithaca, NY.

Robins, C.R., 1957. Effects of storms on shallow-water fish fauna of southern Florida with new records of rish from Florida. Bull. Mar. Sci. 7(3):266-275.

Robinson, S.P., P.D. Theobald, G. Hayman, L.S. Wang, P.A. Lepper, V. Humphrey, and S. Mumford. 2011. Measurement of underwater noise arising from marine aggregate dredging operations-MEPF report 09/P108, Marine Aggregate Levy Sustainability Fund.

Roman C.T., J.A. Peck, J.R. Allen, J.W. King, P.G. Applebee.1997. Accretion of a New England salt marsh in response to inlet migration, storms, and sea level rise. Estuarine, Coastal and Shelf Science 45:717-727.

Rosen, P.S. 1980. Erosion susceptibility of the Virgina Chesapeake Bay shoreline. Marine Geology 34: 45-50.

Rosati, J.D., G.W. Stone, R.G. Dean, and N.C. Kraus. 2006. Restoration of barrier islands overlying poorly consolidated sediments, south-central Louisiana: Gulf Coast Association of Geological Societies Transactions, V. 56, p. 727-740.

Ruppe, Reynold, 1979. The archaeology of drowned terrestrial sites: a preliminary report. Bureau of Historic Sites and Properties. Bull. No. 6, Tallahassee.

Ryder, C. 1991. The effects of beach nourishment on sea turtle nesting and hatch success. Unpublished Report to Sebastian Inlet Tax District Commission, December 1991.

Saini, S., N.L. Jackson, and K.F. Nordstrom. 2009. Depth of activation on a mixed sediment beach. Coastal Engineering 56 (7):788–791.

Sallenger, A.H. Jr., C.W. Wright, P. Howd, K. Doran, and K. Guy. 2010. Extreme coastal changes on the Chandeleur Islands, Louisiana, during and after Hurricane Katrina. Chapter B of Sand Resources, Regional Geology and Coastal Processes of the Chandeleur Islands Coastal System: an evaluation of the Breton National Wildlife Refuge. Edited by D. Lavoie in cooperation with the U.S. Fish and Wildlife Service, Scientific Investigations Report 2009-5252.

Saloman, C.H., Naughton, S.P., and J.L. Taylor, 1982. Benthic community response to dredging borrow pits, Panama City Beach, Florida. Miscellaneous Report 82-3. U.S. Army Corps of Engineers, Coastal Engineering Research Center, Fort Belvoir, VA.

Schubel, J.R., H.H. Carter, R.E. Wilson, W.M. Wise, M.G. Heaton, and M.G. Gross. 1978. Field investigations of the nature, degree, and extent of turbidity generated by open-water pipeline disposal operations. Technical Report D-78-30; U.S. Army Engineer Waterways Experiment Station, Vicksburg, Miss., 245 pp

Scott, L.C. 2014. Benthic community resource monitoring and assessment for the Lower Delaware Bay Prime Hook National Wildlife Refuge Dune Breach Repair Project, DE. Prepared for U.S. Army Corps of Engineers, Philadelphia District by Versar, Inc., Columbia, MD.

Scott, L., 2012. Assessment of benthic macroinvertebrate resources for the expansion areas of D (D2 and D3) Barnegat Inlet to Little Egg Inlet (Long Beach Island) Ocean County, NJ. Prepared for the U.S. Army Corps of Engineers, Philadelphia District by Versar, Inc.

Sexton, N.R., S.C. Stewart, L. Koontz, P. Ponds, and K.D. Walters. 2007. Visitor and community survey results for Prime Hook National Wildlife Refuge: completion report. U.S. Geological Survey, Biological Resources Discipline, Open-File Report 2007-1239. 63 pp.

Shirey, C.A., C.C. Martin, and E.J. Stetzar. 1997. Abundance of subadult Atlantic sturgeon and areas of concentration within the lower Delaware River. Final Report. August 1, 1996-September 30, 1997. Delaware Division of Fish and Wildlife, Dover, DE. 21 pp.

Shirey, C., C.C. Martin, and E.D. Stetzar. 1999. Atlantic sturgeon abundance and movement in the lower Delaware River. DE Division of Fish and Wildlife, Dover, DE, USA. Final Report to the National Marine Fisheries Service, Northeast Region, State, Federal & Constituent Programs Office. Project No. AFC-9, Grant No. NA86FA0315. 34 pp.

Shull, DH , 1997. Mechanisms of infaunal polychaete dispersal and colonization in an intertidal sandflat J Mar Res 55:153-179.

Simpson, P.C. 2008. Movements and habitat use of Delaware River Atlantic sturgeon. Master Thesis, Delaware State University, Dover, DE 128 pp.

Southall, B.L., A.E. Bowles, W.T. Ellison, J.J. Finneran, R.L. Gentry, C.R.J. Greene, D. Kastak, D.R. Ketten, J.H. Miller, P.E. Nachtigall, W.J. Richardson, J.A. Thomas, P. Tyack. 2007. Marine mammal noise exposure criteria: initial scientific recommendations. Aquatic Mammals 33:411-521.

Southwick Associates. 2011. The economics associated with outdoor recreation, natural resources conservation and historic preservation in the United States. The Fish and Wildlife Foundation, Fernandina Beach, FL. 33 pp.

Stedman, S.M. and T.E. Dahl. 2008. Status and trends of wetlands in the coastal watersheds of the Eastern United States 1998 to 2004. National Oceanic and Atmospheric Administration, National Marine Fisheries Service and U.S. Department of the Interior, Fish and Wildlife Service. 32 pp. http://www.fws.gov/wetlands/Documents/Status-and-Trends-of-Wetlands-in-the-Coastal-Watersheds-of-the-Eastern-United-States-1998-to-2004.pdf

Stetzar, E.J. 2002. Population characterization of sea turtles that seasonally inhabit the Delaware Estuary. Master of Science thesis, Delaware State University, Dover, Delaware.136 pp.

Sweka, J.A., J. Mohler, M.J. Millard, T. Kahnle, K. Hattala, G. Kenny, and A. Higgs. 2007. Juvenile Atlantic sturgeon habitat use in Newburgh and Haverstraw Bays of the Hudson River: implications for population monitoring. Transactions of the American Fisheries Society 27:1058-1067.

Taylor, A.C. 1990. The hopper dredge. In: Dickerson, D.D. and D.A. Nelson (Comps.); Proceedings of the National Workshop of Methods to Minimize Dredging Impacts on Sea Turtles, 11-12 May 1988, Jacksonville, Florida. Miscellaneous Paper EL-90-5. Department of the Army, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS. February, 1990. pp. 59-63.

Tetra Tech, Inc. 2004. Archaeological, historical, and geomorphological study of Prime Hook National Wildlife Refuge, Sussex County, DE under contract to the U.S. Fish and Wildlife Service

Thompson, M. 1999. Assessments of the population biology and critical habitat for the horseshoe crab (Limulus polyphemus) in South Carolina. Master's Thesis. The Medical University of South Carolina. Charleston, South Carolina. 136 pp.

Thomsen, F., F. Roose, F. Goethals, A. Kramer, H. Meyer, G. van Raalte, E. San Martin, P. Spadaro, and P. de Wit. 2010. Underwater sounds in relation to dredging. CEDA. The Central Environmental Dredging Association. The Netherlands.

Thrush S.F., R.B. Whitlatch, R.D. Pridmore, J.E. Hewitt, V.J. Cummings, M.R. Wilkinson. 1996. Scale-dependant recolonization: the role of sediment stability in a dynamic sandflat habitat. Ecology 77(8):2472-2487

Tirpak, R.A. and R.A. Thomas. 1981. A cultural resource survey, Prime Hook National Wildlife Refuge, Sussex County, DE. Report for the U.S. Fish and Wildlife Service.

Tyler, A.C., and J.C. Zieman. 1999. Patterns of development in the creek bank region of a barrier island Spartina alterniflora marsh. Marine Ecology Progress Series. V. 180:161-177.

USACE (U.S. Army Corps of Engineers). 1983. Dredging and dredged material disposal. Engineering Manual 1110-2-5025. Washington, DC.

USACE (U.S. Army Corps of Engineers), Philadelphia District. 1997. Delaware River Main Channel Deepening Project (Pennsylvania, New Jersey, and Delaware) Supplemental Environmental Impact Statement.

USACE (U.S. Army Corps of Engineers). 2010. Final programmatic environmental impact statement for the beneficial use of dredged material program. Louisiana Coastal Protection and Restoration Authority. 191 pp.

USACE (U.S. Army Corps of Engineers). 2011. A supplemental biological assessment for potential impacts to the New York Bight distinct population segment of Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*) which is proposed for Federal endangered species listing resulting from the Delaware River Main Stem and Channel Deepening project.

USACE, (U.S. Army Corps of Engineers) 2013. Delaware Estuary regional sediment management plan white paper: Sediment quantity and dynamics. 38 pp.

USACE, (U.S. Army Corps of Engineers) 2014. Environmental assessment for the Barnegat Inlet to Little Egg Inlet (LBI) Storm Damage Reduction Project.

USFWS (U. S. Fish and Wildlife Service). 1982. Environmental assessment for unit III rehabilitation, management and maintenance of wetlands at Prime Hook National Wildlife Refuge, Milton, DE.

USFWS (U. S. Fish and Wildlife Service). 1999. Fulfilling the promise: the National Wildlife Refuge System. Washington, DC.

USFWS (U.S. Fish and Wildlife Service). 2004. A blueprint for the future of migratory birds: migratory bird program strategic plan 2004-2014, 21pp.

USFWS (U.S. Fish and Wildlife Service). 2008. Birds of conservation concern 2008. USDOI, FWS, Division of Migratory Bird Management, Arlington, VA, 85pp.

USFWS (U. S. Fish and Wildlife Service). 2010. Environmental assessment for dune work at Prime Hook National Wildlife Refuge. USDOI – FWS. 71 pp.

Van Dolah, R.F., D.R. Calder, and D.M. Knott, 1984. Effects of dredging and open-water disposal on benthic macroinvertebrates in a South Carolina estuary. Estuaries. 7(1):28-37.

Van Dolah, R.F., M.W. Colgan, M.R. Devoe, P. Donovan-Ealy, P.T. Gayes, M.P. Katuna, and S. Padgett, 1994. An evaluation of sand, mineral, and hard-bottom resources on the coastal ocean shelf off South Carolina. South Carolina Task Force on Offshore Resources Report. 235 pp.

Van Engle, W.A. 1958. The blue crab and its fishery in Chesapeake Bay. Part 1-Reproduction, early development, growth, and migration. Comm. Fish. Rev. 20:6-17.

Vladykov, V.D., and J.R. Greely. 1963. Fishes of the Western North Atlantic 1:24-60.

Vokes, H. 1957. Geography and geology of Maryland. Department of Geology, Mines and Water Resources. Bull. No. 19. Baltimore.

Watling. L. and D. Maurer. 1976. Ecological studies on benthic and planktonic assemblages in lower Delaware Bay. A report to the National Science Foundation, College of Marine Studies, University of Delaware. Newark, DE 650 pp.

Weber. T. 2007. Ecosystem services in Cecil County's green infrastructure. The Conservation Fund, Annapolis, MD.

Weilgart, L.S. 2007. The need for precaution in the regulation and management of undersea noise. J. International Wildlife & Policy. 10:3. 247-253.

Weinstein, M.P., J.M. Teal, J.H. Balletto, and K.A. Strait. 2000. Restoration principles emerging from one of the world's largest tidal march restoration projects. Wetlands Ecology and Management 9:387-407

Wells, H. 1970. *Sabellaria* reef masses in Delaware Bay. Chesapeake Science 11:258–260.

Wilbur, D.H., D.G. Clarke, and M.H. Burlas, 2006. Suspended sediment concentrations associated with a beach nourishment project on the northern coast of New Jersey. Journal of Coastal Research 22(5):1035-1042.

Zajac, R.N. and R.B. Whitlatch, 1991. Demographic aspects of marine, soft sediment patch dynamics. American Zoologist 31:105-128.

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8.0 EVALUATION OF SECTION 404 (b)(1) GUIDELINES

I. Project Description

A. Location

The Prime Hook National Wildlife Refuge (NWR, refuge) was established in 1963 stretching along the southwestern shore of Delaware Bay just north of Cape Henlopen in Sussex County, Delaware. The refuge's eastern boundary runs next to three beachfront communities: Slaughter Beach, Prime Hook Beach, and Broadkill Beach, with some agricultural lands. It currently encompasses 10,144 acres of tidal saltmarshes, agricultural lands and upland forest.

B. General Description

The purpose of the selected plan for the Prime Hook NWR is to restore beaches and marshes by closing shoreline breaches and constructing a marsh platform behind the beach barrier and restoring interior wetland historical tidal channels to a more natural hydrologic circulation for saltmarsh species (*e.g. Spartina* spp.). Tidal influx will provide both a mechanism for sediment transport and should enhance the rate of marsh development. The goal of this plan is to manage the biological diversity, integrity, and environmental health of both the wetlands and interior upland forested areas to sustain high quality habitats for migratory birds, fish and resident wildlife and endangered species.

The beachfill will be designed and constructed under contract by the U.S. Army Corps of Engineers (USACE), Philadelphia District. The project entails placement of beachfill sand obtained from a nearshore borrow area via hydraulic pipeline dredging on 6,375 linear feet of shoreline within the refuge's Management Unit II. The estimated quantity of material need for the beachfill is 1.1 million cubic yards (cy). The sand will be placed on the beach to create a dune and beach berm of uniform cross section. The seaward beach berm will be approximately 220 feet wide and the landward berm will be approximately 70 feet wide at elevation +7.2 North American Vertical Datum (NAVD 88) with a dune at an elevation of +9.8 feet NAVD 88. The dune will be 40 feet wide at its crest and incorporate 7.5 acres of planted dune grasses across the surface of the dune. The dune shall have a total of 11,885 linear feet of sand fence running parallel to the dune along both the seaward and landward toes. The back berm (landward of the dune) will transition to a marsh platform, approximately 400 feet wide and running the length of the beachfill dune with a slope of 75:1 to elevation +1.6 NAVD 88 and then transitioning to a slope of 100:1 until tying into existing ground. Less than 0.5-acre of saltmarsh vegetation may be impacted in this transition zone of the landward sloping berm and the back barrier wetland platform. The back barrier marsh platform has been designed to incorporate the existing shoals which have formed since the breaches occurred. Once sufficient elevations are established on the marsh platform with dredged material, *Spartina* spp. will be planted along approximately 60 acres of the marsh platform. Additionally, natural colonization of *Spartina* and other saltmarsh plants is expected to occur rapidly. The material to construct the marsh platform will be hydraulically pumped from Borrow Area PHB-B (845 acres) located 1.5 to 2.3 miles from the placement area. The length of the back barrier marsh platform is 6,375 linear feet with a 70-foot wide platform crest (landward berm at elevation +7.2 NAVD 88)

The re-establishment of historical tidal circulation channels is an important feature of the refuge's wetland restoration and recovery plan, and will be constructed under contract by the U.S. Fish and Wildlife Service (USFWS, Service). Adjacent and interior of the above-mentioned back barrier transitional marsh platform, a combination of a main channel conveyance and offshoot finger conveyance channels will be

excavated, side-casting the material in an area 150 feet wide adjacent to the excavated channels to enhance habitat diversity within the marsh with both high and low elevation areas. Side-casted material will not be placed on existing vegetation or within historic open water pools. It will be placed alternately on both sides of the channel, so as not to create long linear elevated levees that could restrict flow out of the channel onto the marsh platform. Side-casted material will be strategically placed in lower elevation regions to build up the marsh platform elevation. Approximately 113,739 linear feet of dredged channels will be excavated, side-casting approximately 575,000-675,000 cy of material. Approximately 54.8 acres of mudflat and sand flat within Unit II and 100.7 acres within Unit III of the interior refuge will be dredged to create conveyance channels, with the thin-layered sediments applied to existing intertidal mudflats and sandflats (126.9 acres in Unit II and 257.7 acres in Unit III). It is expected that the thin-layering and reduction in water levels will result in the creation of 1,000 acres of vegetated tidal marsh. Approximately 1,800 linear feet of the easternmost section of Fowler Beach Road, separating Units I and II will be removed to allow for additional *Spartina* colonization. No wetlands will be impacted at any of the three construction staging areas.

The main conveyance channel (approximately 51 feet wide and -3.5 feet NAVD88 with a potential -0.5-foot overcut) will begin at the southernmost end of Management Unit I at Fowler Beach Road traveling south through Management Units II and III and ending in the northernmost portion of Management Unit IV just south of Broadkill Beach Road. Several finger conveyance channels (approximately 27 to 44 feet wide and -2.5 feet NAVD88 with a potential -0.5-foot overcut) will branch off of the main conveyance channel within the interior portions of Management Units II and III to increase tidal circulation throughout the refuge marshes.

C. Authority and Purpose

The Service had previously prepared an Environmental Assessment (EA) in 2010 to evaluate short-term, interim measures to restore protective sand dunes fronting the refuge wetlands. The Service is the primary Federal agency responsible for conserving the nation's fish, wildlife, and their habitats through stewardship of lands. In 2012, the Service prepared a combined Comprehensive Conservation Plan (CCP) and Environmental Impact Statement (EIS). The CCP was required by the National Wildlife Refuge System (NWRS) Administration Act of 1996, as amended by the NWRS Improvement Act of 1997 (16 U.S.C. 668dd, *et seq*.; Refuge Improvement Act). The CCP addresses the management of natural resources at the refuge into the future. Under the National Environmental Protection Act of 1969 (NEPA), the 2012 EIS evaluates alternative measures to achieve the desired future condition of ecosystem protection and restoration and the current EA further evaluates changes in the environment and detailed plan of action.

The appropriation for this project is the Hurricane Sandy Disaster Relief Supplemental Appropriation Act of 2013, Public Law 113-2. Criteria for funding was based on the project's ability to yield the greatest return on investment by taking advantage of existing science and regional planning tools for resiliency and by working with states, cities, communities, and partners who contribute to the goals of restoring and rebuilding national wildlife refuges and other federal public assets; and to increase resiliency and the capacity of coastal habitat and infrastructure and to withstand future storms and to minimize the damage incurred.

D. General Description of Dredged or Fill Material

Results from 50 vibracoring and sediment analyses revealed significant quantities of beach compatible sands reside in the shoals offshore of the refuge from Prime Hook to Slaughter Beach. The shoal materials consist of medium to coarse grained sands and reside in surficial layers ranging from 12 to 20

feet thick. These potential borrow areas are approximately 4,500 to 11,500 feet offshore and contain up to 20 million cy of beach compatible sands. Within the preferred borrow area's (PHB-B) 845 acres, 449 acres have sand thickness of more than 14 feet deep; 246 acres have sand depths ranging from 5 to 14 feet deep; and 95 acres have sand depths less than 5 feet deep). Approximately 55 acres of the site was found to contain no sand. Both Borrow Areas PHB-A and PHB-C possess sand of thicknesses greater than 14 feet throughout. Dredging cut depth will be limited to -5 feet NAVD88. Hydraulic dredges typically cut in a manner that creates ridges approximately 5 feet wide and 200 feet in length.

The material to be dredged within Management Units II and III (approximately 575,000 – 675,000 cy) and side-casted consists of fine-grained clay and silts. Approximately 54.8 acres of mudflat and sand flat within Unit II and 100.7 acres within Unit III of the interior refuge will be dredged to create conveyance channels, with the thin-layered sediments applied to existing intertidal mudflats and sandflats (126.9 acres in Unit II and 257.7 acres in Unit III).

E. Description of Proposed Placement Site

The proposed placement site is comprised of an eroding beach sand berm with exposed underlying peat and inundated saltmarsh and open shallow water areas along the southwestern coastline of the Delaware Bay. The proposed site is unconfined for sand placement on a shoreline. Sediments excavated within the interior of the refuge to re-establish historical tidal flow are predominately organically enriched fine grained sediments (*e.g*. clays, silts) with fine to medium sand deposits in areas adjacent to the active breaches. The material will be thin-layer sprayed within the shallow water area of the northernmost end of Management Unit II, just south of Fowler Beach Road through the southernmost portion of Management Unit III, just north of Broadkill Beach Road. Side-casting material will not be placed on existing vegetation or within historic open water pools, and will be strategically placed in lower elevation areas to build up the marsh platform elevation adequate for plant growth.

F. Description of Placement Method

A hydraulic dredges will be used to excavate the borrow material from the borrow area. The material would be transported using a pipeline delivery system to the berm, dune, and back barrier wetland restoration site. Subsequently, final grading would be accomplished using standard construction equipment. Hydraulic dredges will be used to excavate the channels in the marsh interior, with mechanical excavation also necessary at the dredge deployment sites. Material excavated from the interior of the refuge will be side-casted within the shallow water area proposed for wetland re-establishment.

II. Factual Determination

A. Physical Substrate Determinations

The final proposed elevation of the seaward beach berm after fill placement would be 220 feet wide and the landward berm will be approximately 70 feet wide at elevation +7.2 (NAVD88) with a dune at elevation +9.8 feet (NAVD88). The dune would be 40 feet wide at its crest and incorporate 7.5 acres of planted dune grasses across the surface of the dune. The dune shall have a total of 11,885 linear feet of sand fence running parallel to the dune along both the seaward and landward toes.

The interior channels would consist of 53,262 linear feet of 51-foot wide channels and 60,477 linear feet of 27- to 44-foot wide channels, throughout Management Units II and III. The main conveyance channels

would have a maximum depth of -3.5 feet NAVD 88 (with a potential -0.5 foot overcut), while all other conveyance channels would have a maximum depth of -2.5 feet NAVD 88 (with a potential -0.5-foot overcut).

1. The sediment type involved would be sand along the beach and fine-grained clay and silts within the interior channel construction area.

2. The initial phase of construction would establish a template that is higher than the final intended design profile. It is expected that compaction and erosion would be the primary processes resulting in the change to the design template. Until natural tidal conditions, sand will erode into the water column. Material lost in establishing the template actually serves to create the depth of closure.

3. The interior channels would have an expected 0.5-foot overcut on the vertical excavation (within the channels) and a 3- to 5-foot overcut along the margins or side-slopes of the channel to account for slumping of material that will result after the channel dredging is completed. This will allow the final channel cross-section area to match the intended or planned design.

The proposed construction would result in removal of the benthic community from some of the borrow and channel areas, and burial of the existing beach, nearshore, and adjacent intertidal communities. The dredging methodology in the borrow area is designed to minimize impacts to the borrow area's benthic community recolonization potential by limiting the maximum dredge cut to 5 feet. The cutterhead typically cuts a path approximately 5 feet wide by 150 to 200 feet long, thereby created ridges to mimic natural bottom habitat from currents, and allow for more rapid recolonization of benthic organisms from neighboring untouched bottom substrate.

4. Other effects would include a temporary increase in suspended sediment load and a change in beach profile, particularly in reference to elevation. The elevated turbidity is localized, confined to the beach and/or interior, and short-lived (*i.e.* a few hours or less depending on weather conditions).

5. Actions taken to minimize impacts include selection of fill material that is similar in nature to the pre-existing substrate and conducive to plant propagation on the wetland back barrier platform. In addition, standard construction practices to minimize turbidity and erosion would be employed. Turbidity curtains will be deployed at the water control structures to minimize any excessive turbidity, over background conditions, which could impact the adjacent waterways.

B. Water Circulation, Fluctuation, and Salinity Determinations

1. Water. Consider effects on:

a. Salinity - No effect.
b. Water Chemistry - No significant effect on the beach construction and only potentially short-term impacts in the marsh interior.
c. Clarity - Minor short-term increase in turbidity during construction.
d. Color - No effect.
e. Odor - Minor short-term effect in the marsh interior.
f. Taste - No effect.
g. Dissolved gas levels - No significant effect.
h. Nutrients - Minor short-term effect.
i. Eutrophication - No effect.
j. Others as appropriate - None.

2. Current patterns and circulation

a. Current patterns and flow - Circulation would only be impacted by the proposed work in the immediate vicinity of the borrow area, and in the placement area where the existing circulation pattern would be offset seaward the width of the berm and dune restoration. The current patterns and flow in the marsh would be restored to a more natural condition at the completion of the channel construction.

b. Velocity - No effect on tidal velocity and longshore current velocity regimes.

c. Stratification - Thermal stratification occurs beyond the mixing region created by the surf zone. The normal pattern should continue post construction of the proposed project.

d. Hydrologic regime - The regime is marine and estuarine. This would remain the case following construction of the proposed project.

3. Normal water level fluctuations - the tides are semidiurnal with a mean tide range of 4.6 feet and a spring tide range of 5.4 feet in the Delaware Bay. Construction of the proposed work would not affect the tidal regime at the beach. The interior peak water levels are expected to be reduced by 21 percent to 45 percent, which could reduce the tidal range within the marsh interior.

4. Salinity gradients - There should be no significant effect on the existing salinity gradients at the beach. Peak salinities within the marsh interior are expected to be reduced to more natural conditions compared to existing measured data. Brackish to salt conditions will still be present due to the connection of the refuge to Delaware Bay via Slaughter Canal and the Broadkill River. The salinities in Management Unit III are expected to see the greatest reduction, as Prime Hook Creek provides a significant source of freshwater to the refuge, and the conveyance channel creation will aid in distributing the saltwater more effectively to the eastern portion of Unit III and allowing the freshwater boundary to expand further to the east.

5. Actions that would be take to minimize impacts - Hydraulic dredges typically cut in 5 feet wide by 150 to 200 feet long swaths and create areas of high and low relief similar to natural ridge slopes to ensure normal water exchange and circulation. Utilization of clean sand and its excavation with a hydraulic dredge would also minimize water chemistry impacts. Additionally, sand pumped onto the lower beach can be formed into a sand dike to reduce turbidity runoff into the bay during berm construction. Turbidity curtains will be deployed at the existing water control structures to reduce the potential for excess turbidity to enter the adjacent waterways. Seasonal windows will be adhered to avoid impacts to both marine and terrestrial species.

C. Suspended Particulate/Turbidity Determinations

1. Expected changes in suspended particulate and turbidity levels in the vicinity of the placement and borrow sites - There would be a short-term elevation of suspended particulate concentrations during construction phases in the immediate vicinity of the dredging and discharge activities.

2. Effects (degree and duration) on chemical and physical properties of the water column

a. Light penetration - Short-term, limited reductions would be expected at the borrow and beach placement sites and in the marsh interior, from dredge activity and berm runoff.

b. Dissolved oxygen - There is a potential for a decrease in dissolved oxygen levels but the anticipated low levels of organics in the borrow material should not generate a high, if any, oxygen demand.

c. Toxic metals and organics - Because the borrow material is essentially fine to medium sand, as defined by the Unified Soil Classification System, no toxic metals or organics are anticipated. It is not anticipated that toxic metals and organics will be present in the marsh

interior, as the adjacent land-uses do not lend themselves to increasing the potential for those chemical constituents of concern, but plans are in place to conduct a detailed toxic metal and organic compound assessment.

d. Pathogens - Pathogenic organisms are not known or expected to be a problem in the borrow or placement areas.

e. Aesthetics - Construction activities and the initial construction template associated with the beach and dune fill and the thin-layer application sites would result in a minor, short-term degradation of aesthetics.

3. Effects on Biota

a. Primary production, photosynthesis - Minor, short-term effects related to turbidity.

b. Suspension/filter feeders - Minor, short-term effects related to suspended particulates outside the immediate deposition zone. Some sessile organisms would be subject to burial within the deposition area.

c. Sight feeders - Minor, short-term effects related to turbidity.

4. Actions taken to minimize impacts include utilization of uncontaminated borrow material, creation of a temporary small sand dike along the foreshore during berm construction to reduce elevated turbidity from runoff. Turbidity curtains will be deployed at the existing water control structures to reduce the potential for excess turbidity to enter the adjacent waterways. Standard construction practices would also be employed to minimize turbidity and erosion.

D. Contaminant Determinations

The discharge material is not expected to introduce, relocate, or increase contaminant levels at either the borrow or placement sites. This is assumed based on the characteristics of the sediment, the proximity of borrow sites to sources of contamination, the area's hydrodynamic regime, and existing water quality.

E. Aquatic Ecosystem and Organism Determinations

1. Effects on plankton -The effects on plankton should be minor and mostly related to light level reduction due to turbidity. Significant dissolved oxygen level reductions are not anticipated.

2. Effects on benthos - There would be a minor disruption of the benthic community in that only portions of the borrow area will be impacted by the dredge (*i.e.* typical hydraulic dredge cuts are about 5 feet wide). Some burial or displacement of infaunal organisms will occur at the placement site within the intertidal zone. The loss is somewhat offset by the expected rapid opportunistic recolonization from adjacent areas that would occur following cessation of construction activities. Recolonization is expected to occur at the placement site by vertical migration also. Some marine invertebrates within the interior marsh in areas where channel excavation and sidecasting of the material occurs will be disrupted.

3. Effects on Nekton - Only a temporary displacement is expected as the nekton would probably avoid the active work areas. The dredge pipeline will be floated to minimize impacts to benthics and finsfish.

4. Effects on Aquatic Food Web - Only a minor, short-term impact on the food web is anticipated. This impact would extend beyond the construction period until recolonization of the buried area has occurred and fish return to the area after construction.

5. Effects on Special Aquatic Sites - No wetlands would be impacted by the project's dune and berm construction. The majority of wetlands in the area of the proposed back barrier wetland platform construction have been converted to open shallow water habitat and minimal vegetation remains due to insufficient substrate elevations and tidal inundation. Restoration of these saltmarshes is considered a positive impact.

6. Threatened and Endangered Species - Several species of threatened and endangered sea turtles may occur in the vicinity of the sand borrow areas depending on time of year. Current practices require the use of screens placed on the dredge draghead or cutterhead as well as the beach discharge pipe, for the prevention of ordnance deposition on beaches. This method serves to minimize impacts to sea turtles as well, and has been coordinated with the National Marine Fisheries Service. There are no known threatened or endangered species within the interior marsh proposed for tidal channel excavation.

The piping plover, a Federal and State threatened species, and the candidate species Red Knot could potentially occur in the project area but is not likely to be present as preferred sandy beach habitat in the project area is significantly eroded and primarily submerged. The species is not likely to be impacted by construction of the proposed project as they are seasonal and migratory and construction is not expected to occur during the spring and summer months. Once constructed, the project could provide more suitable nesting habitat for the migratory shorebirds and other beach nesters. Refuge staff can monitor the project area during construction to provide means that will serve to minimize impacts to nesting least terns and black skimmers.

7. Other wildlife - The proposed plan may temporarily cause wildlife species that forage within the shallow waters to leave the area. Upon completion of construction, the established wetlands will provide improved habitat.

8. Actions to minimize impacts - Impacts to benthic resources can be minimized at the borrow area by dredging in a manner as to avoid the creation of deep pits, and create ridges that mimic the natural sand waves that result from currents. Hydraulic cutter suction dredges cut lanes approximately 5 feet wide by 200 feet long and will be limited to a depth of 5 feet deep of surrounding bathymetry. Employing dragarm and cutterhead intake screens minimizes the potential for impacts to Federal and State threatened or endangered sea turtles. Although highly unlikely, in the event that the Federal and State threatened piping plover was found at the project site, impacts to the species can be avoided or minimized by establishing a buffer zone around nests during the nesting season. The pipeline will be floated so as to minimize impacts to fish. For channel excavation, the material will be side-casted in 150-foot wide reaches to enhance habitat variability with both high and low elevation areas to promote vegetative growth. Side-casted material will not be placed on existing vegetation or within historic open water pools.

F. Proposed Placement Site Determinations

1. Mixing zone determination

a. Depth of water - Zero to -15 feet mean low water

b. Current velocity - Predominate current is longshore current which is wind dependent for its velocity in shallow water. The current velocities in the marsh interior are due to tidal forcing, but wind forcing can significantly affect water movement as well.

c. Degree of turbulence – minimal to moderate.

d. Stratification – None.

e. Discharge vessel speed and direction - Not applicable.

f. Rate of discharge - Typically this is estimated to be 780 cy per hour for the berm and dune discharge along the beach and 270 cy per hour for the marsh interior.

g. Dredged material characteristics – predominantly fine to medium sand as defined by the Unified Soil Classification System for the beach and dune construction, and clay to silt for the channel excavation .

h. Number of discharge actions per unit time - Continuous over the construction period.

2. Determination of compliance with applicable water quality standards - a Section 401 Water Quality Certificate and consistency concurrence with the Delaware Department of Natural Resources and Environmental Control will be obtained prior to initiation of construction. Determination of compliance for Department of the Army permits under Section 10 of the Rivers and Harbors Act of 1899 and Section 404 of the Clean Water Act, as amended in 1977.

3. Potential effects on human use characteristics

a. Municipal and private water supply - No effect.

b. Recreational and commercial fisheries - Short-term effects during construction.

c. Water related recreation - Short-term effect during construction.

d. Aesthetics - Short-term effect during construction.

e. Parks, national and historic monuments, national seashores, wilderness areas, etc. - Short- term effect during construction of a small portion of the wildlife refuge.

G. Determination of Cumulative Effects on the Aquatic Ecosystem - None anticipated. Wetland restoration is anticipated to result in an improvement in habitat quality, quantity, and water quality through erosion control and the establishment of more wetland vegetation.

H. Determination of Secondary Effects on the Aquatic Ecosystem - Any secondary effects would be minor and short in duration.

III. Finding of Compliance or Non-Compliance with the Restrictions on Discharge

A. No significant adaptation of the Section 404(b)(1) Guidelines was made relative to this evaluation.

B. The alternative measures considered for accomplishing the project are detailed in the CCP/EIS Statement (2012) and Section 2.4 of this EA.

C. A Section 401 Water Quality Certificate and Federal Consistency Determination will be obtained from the Delaware Department of Natural Resources and Environmental Control.

D. The proposed berm/dune/wetland restoration would not violate the Toxic Effluent Standards of Section 307 of the Clean Water Act.

E. The proposed berm/dune/wetland restoration would comply with the Endangered Species Act of 1973.

F. The proposed berm/dune/wetland restoration would not violate the protective measures for any Marine Sanctuaries designated by the Marine Protection, Research, and Sanctuaries Act of 1972.

G. The proposed berm/dune/wetland restoration would not result in significant adverse effects on human health and welfare, including municipal and private water supplies, recreation and commercial fishing, plankton, fish, shellfish, wildlife, and special aquatic sites. Significant adverse effects on life stages of aquatic life and other wildlife dependent on the aquatic ecosystem; aquatic ecosystem diversity, productivity, and stability; and recreational, aesthetic, and economic values would not occur.

H. Appropriate steps to minimize potential adverse impacts of the discharge on aquatic systems include selection of borrow material that is uncontaminated sand.

I. On the basis of the guidelines, the placement site for the dredged material is specified as complying with the requirements of these guidelines, with the inclusion of appropriate and practical conditions to minimize pollution or adverse effects on the aquatic ecosystem.